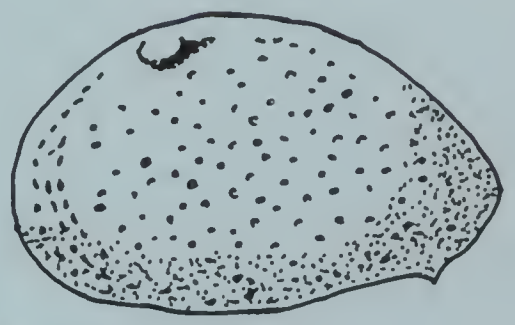


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THE JURASSIC AND CRETACEOUS OF EASTERN
ENGLAND

R.H. BATE & I.P. WILKINSON



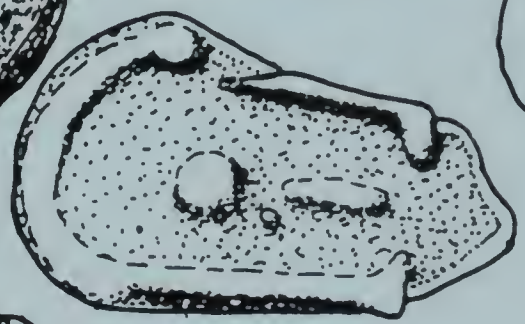
S. bilobata



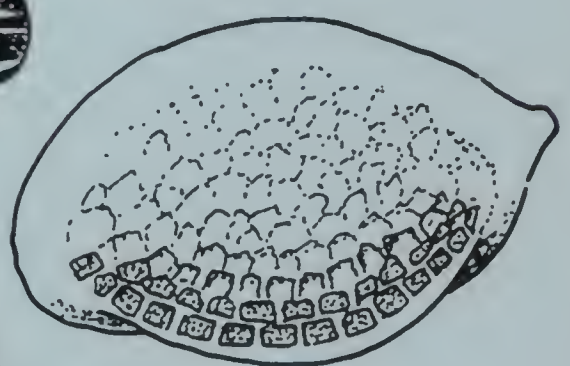
H. reticulata



M. sexti



R. senckenbergi



C. triebeli



A. hauteriviana



C. exquisita



P. rodewaldensis



S. acuminata

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THE JURASSIC AND CRETACEOUS OF EASTERN ENGLAND

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MONDAY 18th JULY

Depart from London

LOCALITY 1: Barrington, near Cambridge (Upper Albian to Cenomanian).

LOCALITY 2: Norman Cross Quarry, near Peterborough (Callovian &
Oxfordian).

TUESDAY 19th JULY

LOCALITY 3: Ketton, near Stamford (Bathonian).

LOCALITY 4: Kirton in Lindsey Quarry, northern Lincolnshire (Bajocian).

WEDNESDAY 20th JULY

LOCALITY 5: Nettleton Quarry near Caistor (Neocomian).

LOCALITY 6: South Ferriby, South Humberside (Oxfordian, Lower
Kimmeridgian, Albian and basal Cenomanian).

LOCALITY 7: Reighton Sands, Speeton (Upper Kimmeridgian, Ryazanian to
Albian and basal Cenomanian).

THURSDAY 21st JULY

A morning site seeing in York

LOCALITY 8: Robin Hood's Bay (Sinemurian & Pliensbachian).

FRIDAY 22nd JULY

LOCALITY 9: The South Cave area, North Humberside (Middle Jurassic).

LOCALITY 10: Cloughton (Bajocian)

SAT 23rd JULY

Morning sight-seeing in Yorkshire.

LOCALITY 11: Cayton (Middle & Upper Jurassic).

SUN 24th JULY

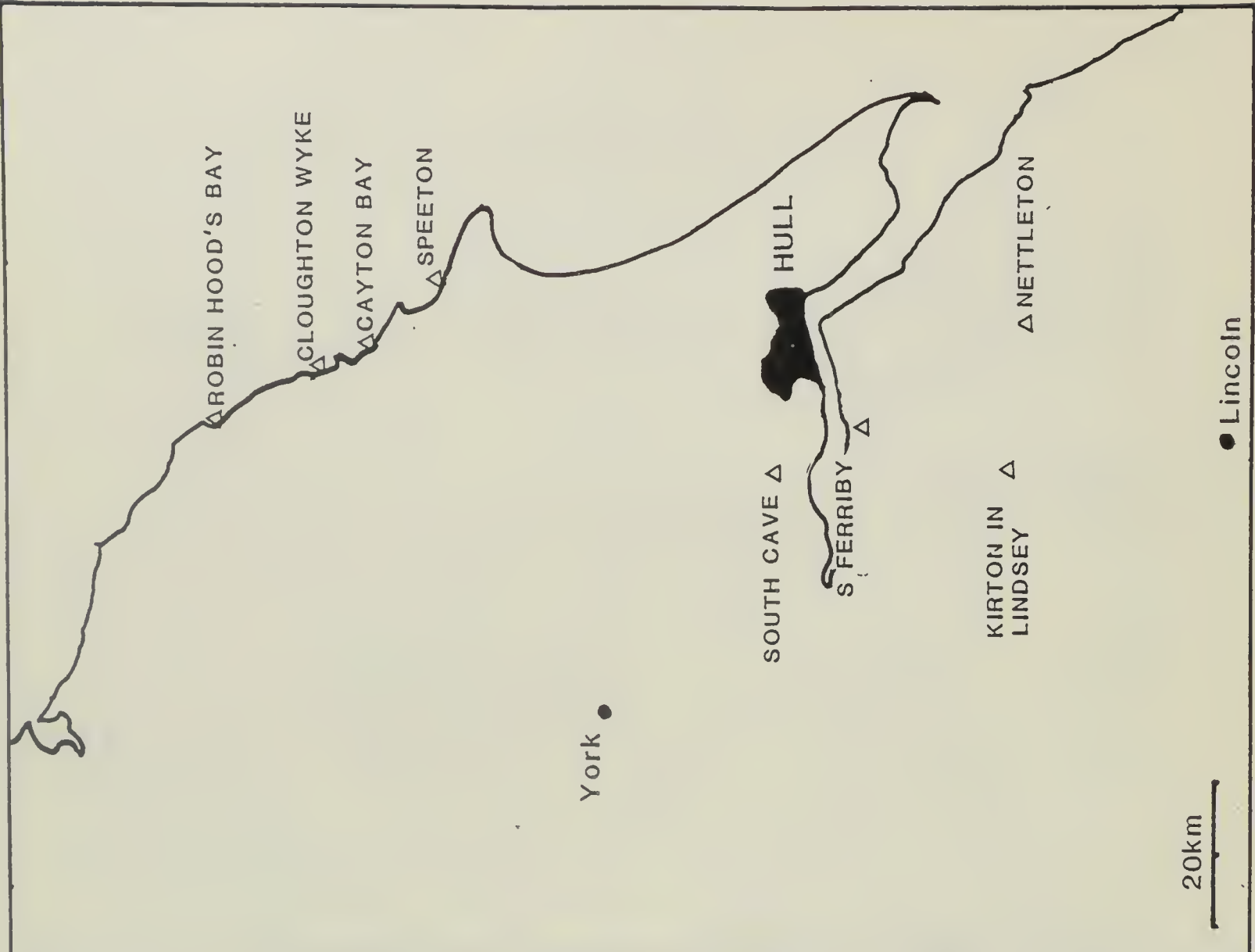
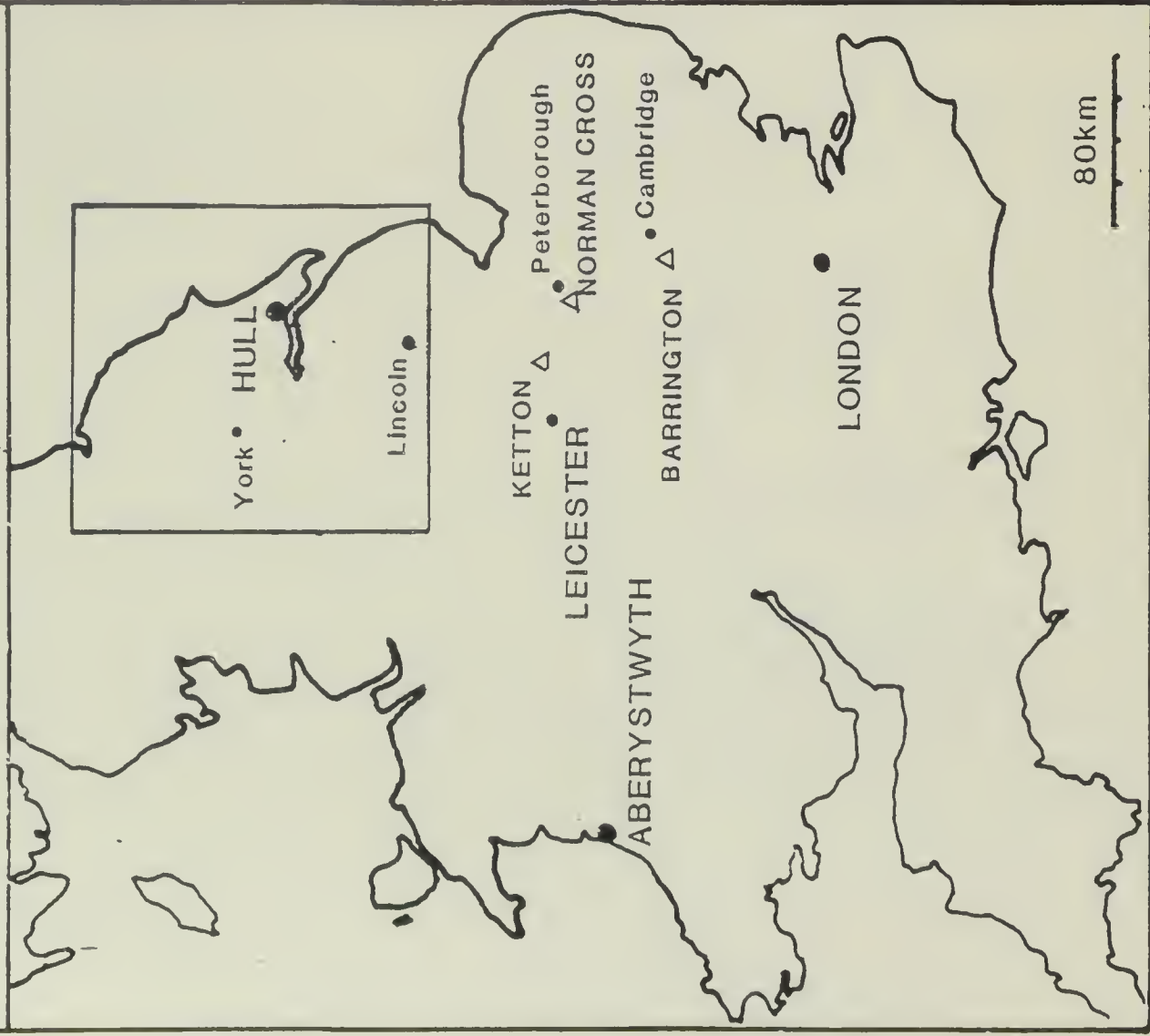
Depart for Aberystwyth.

The authors wish to thank the companies and land owners of the localities mentioned in this field guide, for allowing access to their quarries. That part of the field guide that was written by I.P. Wilkinson is published by permission of the Director of the British Geological Survey (N.E.R.C.).

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PRE-SYMPOSIUM EXCURSION NO.2

THE JURASSIC AND CRETACEOUS
OF EASTERN ENGLAND



STRATIGRAPHY

The stratigraphy of eastern England has been a topic of research for well over 150 years, yet despite this, knowledge has remained incomplete. This is particularly true away from the coast where exposure is limited; in the past, great reliance was placed on quarries, many of which are no longer extant, but more recently boreholes have produced much important data. It has been summarised several times, eg. Larwood (1961) and Gallois (1984) for East Anglia; Kent (1980) for Lincolnshire and Humberside; and Neale (1974) and Hemingway (1974) for Yorkshire. The Geological Society Special Reports (Rawson et al., 1978; Cope, Getty, et al., 1980; Cope, Duff, et al., 1980) form excellent guides to the stratigraphy of the area.

LOWER JURASSIC

The Lower Jurassic is especially well developed in the classical coastal sections of north east England, where the Lias outcrop rivals the excellent exposures of Dorset to the south.

Although the base of the Hettangian is not visible in Yorkshire, there is an otherwise complete section exposed through to the Middle Jurassic. Classical sections to examine are the ironstone-rich Cleveland Ironstone Formation of the Middle Lias, the hydrocarbon-rich Jet Rock and Bituminous Shales and the Alum Shales of the Toarcian, so important historically for the extraction of alum.

Unlike the sequence in Dorset, the Lias of Yorkshire is dominantly a very hard, dark grey mudstone that daunts the micropalaeontologist. Ostracods are either difficult or impossible to extract and consequently

detailed published work on the ostracods is very sparse. Only the Sinemurian and Pliensbachian will be examined on this field excursion.

THE LOWER LIAS shales of Robin Hood's Bay are excellently exposed as a series of scars running out to sea. Viewed from the cliff top, scars may be seen to bend round to form a large anticlinal structure. Here the axis of the Cleveland Basin runs approximately east-west through the North Yorkshire Moors to produce a striking geological feature at Robin Hood's Bay.

MIDDLE JURASSIC

The Middle Jurassic sediments of north eastern England are most completely developed in the Yorkshire Basin to the north of the stable structure known as the Market Weighton Block. To the west of the block lay land and to the east was open sea, but deposition in the subsiding basins to the north and south of it, produced somewhat different facies. Because of the different facies encountered, the areas north and south of Market Weighton will be treated separately.

The Cleveland Basin, in Yorkshire, was the depositary for thick fluviatile and deltaic sediments whose deposition was interrupted by periodic marine transgressions, some of which are recognisable to the south of the Market Weighton Block.

To the south, the Lincolnshire Basin has the following succession at outcrop:

- 3. Bathonian Blisworth Clay
 Blisworth Limestone
 Upper Estuarine Series
- 2. Bajocian Upper Lincolnshire Limestone
 Lower Lincolnshire Limestone

1. Aalenian Basement Beds
 Lower Estuarine Series
 Northampton Ironstone Formation

THE NORTHAMPTON IRONSTONE FORMATION has been extensively quarried for ironstone in the past, but is no longer a commercial proposition. Ammonites are rare and are all indicative of the Opalinum Zone.

THE LOWER ESTUARINE SERIES is almost certainly not of estuarine origin and would appear to be of freshwater depositon and virtually barren of ostracods. Those fossils listed would suggest a fluviatile environment.

THE BASEMENT BEDS are marine clays with thin limestones that environmentally appear to have been deposited in a quiet marine environment, lacking any trace of wave current action. The ostracod faunas recorded (Bate, 1963), suggest a shallow, almost lagoonal environment with all instars preserved. Geographically, the extent of these beds appears to be restricted to the area immediately south of Market Weighton. The ostracod fauna present dates these beds to the Aalenian.

THE LINCOLNSHIRE LIMESTONE, probably no younger than Discites to Laeviuscula Zone age (Bajocian), or at least not yet proven to be so, is a thick oolitic limestone that extends eastwards around the Market Weighton Block to transgress the Yorkshire delta as an oolite (formerly Millepore Oolite) now referred to as the Cayton Bay Formation. Divisible into an Upper and a Lower Lincolnshire Limestone, several local facies are developed; the more marly facies of the Lower Lincolnshire Limestone coming in as the oolite approaches the Market Weighton Block.

The top of the Upper Lincolnshire Limestone is often seen as a hard ground, overlain by Bathonian marginal marine/lagoonal deposits that comprise the Upper Estuarine Series. This series consists of interbedded

shallow marine clays (containing Upper Bathonian ostracods) and freshwater clays with ostracods and in situ plant remains. The Upper Estuarine Series has been interpreted as the product of longshore drift southwards from the Yorkshire delta, very much as occurs at the present day, but on a much larger scale, along the Texas coast west of the Mississippi delta.

THE BLISWORTH LIMESTONE and overlying BLISWORTH CLAY are Upper Bathonian marine sediments of localised extent only. To the south west, they pass laterally into marine and marginal marine sediments of Oxfordshire. In north east England, the Bathonian is a very near shore deposit. Dating by traditional methods using ammonites is dubious, very few specimens being found in situ. Their rarity suggests that the environment was almost certainly not to their liking.

The area around Market Weighton is well described by Neale (1958) while the Lincolnshire area, to the south, has been dealt with in detail by Sylvester-Bradley and Ford (1968). To the north of Market Weighton, a radical change in stratigraphical terminology has taken place during recent years, together with a review of the environment of deposition of the marine and non-marine sediments. The following up-to-date stratigraphy is taken from Hemingway (1974):

Bathonian	Scalby Formation
Bajocian	Scarborough Formation
	Cloughton Formation
	Cayton Bay Formation
	Cloughton Formation
	Blowgill Formation
Aalenian	Eller Beck Formation
	Hayburn Formation
	Yorkshire Dogger Formation

The Aalenian to Bathonian interval spans a period of time during which fluviatile and deltaic sediments were deposited. The HAYBURN, CLOUGHTON (split in the southern part of the basin by the marine oolitic CAYTON BAY FORMATION) and SCALBY FORMATIONS are the clastic sequences of fluviatile and deltaic origin. These extensive phases of sedimentation are subdivided by marine phases that transgressed over the basin, namely: the DOGGER FORMATION, ELLER BECK and BLOWGILL FORMATIONS, the CAYTON BAY FORMATION, SCARBOROUGH FORMATION and finally, the CORNBURASH FORMATION, after which period of time, deltaic conditions did not return.

The area around South Cave, just to the south of the Market Weighton Block, is of interest in that here there is a transition between the Yorkshire sediments to the north and those of the Lincolnshire basin to the south. The Cave Oolite, for example, is the lateral equivalent of both the Lincolnshire Limestone and of the Cayton Bay Formation. It is overlain by sands that mark the crest of the block and represent a very shallow marine deposit, possibly emergent at times. Further south, probable remnants of the Scarborough Formation have been found in a borehole drilled at Nettleton (Bradshaw & Penney, 1982). This indicates that younger Bajocian sediments were deposited more widely in north Lincolnshire, but were generally removed before deposition of the Bathonian Upper Estuarine Series.

UPPER JURASSIC

Hemingway (1974) described the Upper Jurassic stratigraphy of Yorkshire:

Kimmeridgian Kimmeridge Clay

Oxfordian Upper Calcareous Grit Formation

	Coralline Oolite Formation
	Lower Calcareous Grit Formation
	Oxford Clay Formation
Callovian	Hackness Rock Formation
	Kellaways Rock Formation
	Cornbrash Formation

Following the fluviatile, deltaic and very shallow marine deposition of the Middle Jurassic and Callovian (when the Cornbrash, Kellaways and Hackness Rock formations accumulated), a major transgression began, with marine clastics dominating over carbonate facies.

The transgression that gave rise to the OXFORD CLAY FORMATION was relatively brief in Yorkshire compared to that in southern England, and only the Lower Oxfordian is present in the Oxford Clay facies (eg. Mariae Zone at Cloughton). The Lower and Upper Calcareous Grit formations, separated by the Coralline Oolite Formation, forming much of the Oxfordian.

In Lincolnshire and East Anglia, however, the soft calcareous mudstones that comprise the Oxford Clay, can be dated, using ammonites, to the Calloviense to Lamberti Zones, although much of the formation is poorly exposed. The West Walton Beds and Ampthill Clay overlie the Oxford Clay in the area around The Wash. The former comprises pale grey, soft, silty mudstones, in part very calcareous, and numerous cementstones. The latter consists of darker grey mudstones, the silt content decreasing upwards, with phosphatic nodule beds in the higher part. Gallois and Cox (1977) recognised sixteen beds in the West Walton Beds, which date to the late Cordatum to early Tenuiserratum zones, and a further forty two beds in the Ampthill Clay, which is of late Tenuiserratum to (?)Regulare zonal age.

The KIMMERIDGE CLAY FORMATION outcrops almost continuously from Dorset to South Humberside and the Vale of Pickering, Yorkshire, although exposure is poor. The formation is composed of a series of beds in small-scale cycles that can be traced throughout England and the Southern North Sea Basin (Gallois & Cox, 1974, 1976; Cox & Gallois, 1979, 1981). Beds are based on a combination of lithology and macrofaunal characteristics and are remarkably consistent throughout eastern England, suggesting consistent environmental conditions prevailed throughout the area at any particular time. Tyson et al. (1979) considered that the cause of the cycles was the result of the vertical movement of the O_2 : H_2S interface in a temporarily stratified water column. The movement of this interface played a dominant role in controlling the faunas found in each lithology throughout southern and eastern England.

In East Anglia, the Kimmeridge Clay thins to the south-east due to the combined effect of attenuation onto the London-Brabant High and overstepping by the Sandringham Sands. It reaches a maximum around The Wash (c.130m compared to c.490m in Dorset), but it is reduced to c.60m at Downham Market, 8m at Mundford and zero south east of Mundford. Facies close to the high are variable in eastern England, so that the Lower Kimmeridge Clay at, for example, Mundford, is condensed and sandier compared to areas further north. The effect of erosion in South Humberside has resulted in rapid thinning to the north, but individual beds within the preserved Kimmeridge Clay, suggests that there was relatively little or no thinning over the Market Weighton Block. The age of the Kimmeridge Clay in eastern England ranges from the Baylei Zone, at the base, up into the

Pectinatus Zone at the top. The highest zones seen in Dorset were removed by erosion prior to the deposition of the Sandringham and Spilsby Sands.

JURASSIC/CRETACEOUS BOUNDARY BEDS

The SANDRINGHAM SANDS FORMATION accumulated during the latest Jurassic and earliest Cretaceous, and are essentially arenaceous. In two classic papers by Casey (1973) and Casey & Gallois (1973), the Sandringham Sands are divided into four members: Roxham, Runcton, Mintlyn and Leziate members. Ostracods have not been found in this deposit.

The SPILSBY SANDSTONE FORMATION, in Lincolnshire, is coeval with much of the Sandringham Sand Formation of Norfolk. A bipartite division has been recognised by Casey (1963, 1973), the interformational boundary being taken at the Mid-Spilsby Nodule Bed. However, only the Lower Spilsby Member is present north of Tealby and the formation finally disappears north of Clixby. Ostracods have not been found in the formation

LOWER CRETACEOUS

The DERSINGHAM FORMATION, consist of arenaceous deposits (fine sands with silts and subordinate, thin beds of clay) and the thin, argillaceous Snettisham Clay, in the southern part of Norfolk (Casey & Gallois, 1973).

The CLAXBY FORMATION of Lincolnshire is coeval with the upper part of the Sandringham Sand Formation (uppermost Mintlyn and Leziate Members) and basal part of the Dersingham Formation. It consists of two facies, the arenaceous Claxby Ironstone Member that is present through much of the county and the argillaceous Hundleby Clay Member which is confined to the south.

The base of the formation is diachronous. In the south of the county, the base of the Hundleby Clay and Claxby Ironstone falls within the P.

albidum Zone (Late Ryazanian). Further north at Benniworth Haven and Nettleton Hill, the basal bed of the Claxby Ironstone Member contains macrofaunas of, respectively, the Paratollia and Polyptychites zones (Early Valanginian) (Kemper, Rawson & Thieuloy, 1981; Kelly & Rawson, 1983; Rawson, Curry, Dilley, et al., 1978).

The Claxby Ironstone Member consists of a somewhat condensed, clayey, oolitic ironstone. In northern Lincolnshire the best exposure is at Nettleton Hill. Here, the member consists of a thin basal pebbly grit, overlain predominantly by oolitic (limonite) wackestone in an argillaceous matrix, although it is somewhat sandier in the lower part. The top of the Claxby Ironstone Member, which is distinctly calcareous and has been termed the 'calcareous beds' by some authors (eg. Kemper et al., 1981; Kelly & Rawson, 1983), has been shown to fall within the E. amblygonium to E. noricum zones (basal Hauterivian). The ironstone member, passes laterally into the Hundleby Clay, a purple-grey and brown-mottled silty clay that becomes sandier towards the top.

The TEALBY FORMATION can be divided into three:

3. Upper Tealby Clay Member
2. Tealby Limestone Member
1. Lower Tealby Clay Member

The LOWER TEALBY CLAY MEMBER comprises heavy blue-grey clay, rich in glauconite at some levels, and sometimes silty or oolitic in southern and central Lincolnshire. In northern Lincolnshire the lower part of the member is particularly oolitic and difficult to separate from the Claxby Formation, eg. at Nettleton Hill Quarry. In southern and central Lincolnshire, the lowest beds fall within the E. regale Zone, but at Nettleton the base of the formation is placed in the S. inversus Zone (Rawson, 1971) and the highest part of the member has a S. marginatus or

early S. variabilis zonal age (Rawson, Curry, Dilley, et al., 1978; Rawson & Mutterlose, 1983).

The TEALBY LIMESTONE MEMBER consists of sandy limestones and oolitic clays. Although the base is sometimes difficult to define due to its somewhat gradational nature, the upper boundary is clearer, being placed above of ferruginous limestone with abundant, large oysters (Ussher et al., 1888). It is variable in lithology, varying from thick and hard limestones around Nettleton to thinner, softer and more argillaceous deposits in the south. The member falls within the S. variabilis to P. fissicostatum zones (Rawson, Curry, Dilley et al., 1978; Rawson & Mutterlose, 1983).

The UPPER TEALBY CLAY MEMBER, in southern and central Lincolnshire, consists of grey and buff clays that are silty at some horizons and occasionally glauconitic. North of Goulceby, however, the member thins rapidly and it is not present north of Normanby. Its zonal age is probably P. fissicostatum to P. denkmanni, however, ammonites have not been found and the postulated age is dependent on secondary evidence provided by belemnites (Rawson & Mutterlose, 1983).

The FULLETTY FORMATION is called the 'Roach' by some authors. In Lincolnshire the formation consists of argillaceous deposits that can be divided into three by a ferruginous sand ('Roach Stone') in the middle part. The lower argillaceous member consists of brown ferruginous silty clay with scattered pebbles, but it becomes progressively more oolitic up from its base and is particularly arenaceous just below the Roach Stone Member. The latter is a brown sand, less ferruginous, but more calcareous than preceeding deposit and sometimes oolitic. The upper member shows a reversion to ferruginous silts, the proportion of ooliths decreasing upwards. The formation, which thins northwards due to overstepping by the Carstone, is difficult to date due to the poor faunas. However, the

belemnites are indicative of a Late Barremian (?late P. denckmanni to ?early P. bidentatum zones) age.

The SUTTERBY FORMATION is a sequence of argillaceous deposits between the arenaceous Fulletby and Carstone Formations. Deposited during the Aptian, it consists of medium and dark grey clays (Skegness Clay Member) overlain disconformably by pale grey marls (Sutterby Marl Member) and is restricted to The Wash and southern Lincolnshire. The former, which has not been recognised at surface, is of the P. bodei Subzone, P. fissicostatus Zone, whereas the latter is Late Aptian.

The FERRIBY CHALK FORMATION was originally erected by Wood & Smith (1978) to include the so called "Red Chalk" and overlying white chalk at South Ferriby. As they pointed out, the formation passes down into the Carstone, the stratigraphically earliest preserved deposit associated with the major Albian transgression. Rawson (in press) redefines the formation to include the Carstone, which is given member status.

The CARSTONE MEMBER is a medium to coarse grained, pebbly, oolitic, ferruginous sand which was deposited as an offshore bar aligned parallel to the emergent London-Brabant Massif Gallois & Morter (1982). The Carstone thins and finally disappears on the flanks of the London-Brabant Massif. Much of the Carstone is unfossiliferous and the age of the deposit has been a matter of controversy, but Casey (1967) showed it to be Early Albian in age, with the recovery of brachiopods that permitted correlation with the Shenley Limestone (L. tardifurcata Zone) of Leighton Buzzard. The Carstone passes up into the Hunstanton Chalk Member and the Gault via silty beds.

The HUNSTANTON CHALK MEMBER is coeval with the Gault. It has been called 'Red Chalk' by several authors, but this is unsatisfactory because at several horizons the coloration fails as a result of sulphidisation

during diagenesis (Jeans, 1980), when it becomes pale pink, yellow, cream or white. Indeed, the lowest part of the white Chalk that has generally been regarded as Cenomanian in age, is Albian in some regions of eastern England. It is for this reason that Wood & Smith (1978) renamed it "Hunstanton Chalk Member".

Jeans' (1973, pp.419-420) definition of the Hunstanton Chalk Member for Yorkshire, is applicable to the deposit in the whole of the area. It "consists of marls, nodular chalks and porcellaneous chalks which may contain horizons of limestone pebbles; it is usually a conspicuous red colour. The basal beds....are either transitional to the underlying Carstone or Speeton Clay, or they may rest with obvious disconformity on Jurassic rocks. At its upper limit the Red Chalk is marked by either an extensive bored chalk surface or by an horizon of stromatolites....the upper limit is taken at the first appearance in abundance of terebratulid brachiopods not of 'Terebratula' biplicata type." Morter (in press) defined eleven beds based on the South Ferriby Quarry exposure (numbered from the bottom up). Based on a combination of lithology and macropalaeontology, they can be traced throughout the county and, with only a little difficulty, to Hunstanton.

The GAULT FORMATION in East Anglia is poorly exposed due to the extensive superficial deposits and most work has been carried out using borehole material (Gallois & Morter, 1982). A series of small scale (c.2m) rhythms caused by fluctuations in sea level occurs throughout the formation in East Anglia. Each rhythm begins with a medium to dark grey, silty, shelly, pebbly mudstone or siltstone resting on a bioturbated, eroded surface. A fining upward sequence together with an increase in calcium carbonate then follows, so that the top part is a medium to pale grey mudstone. The upper surface is eroded by the succeeding rhythm.

Deposition is believed to have taken place in the shallow water of an elongate trough that ran parallel to the coast of the emergent London-Brabant Massif (Gallois & Morter, 1982).

The age of the Gault in eastern England extends from the H. dentatus ammonite Zone, L. lyelli Subzone, at the base, to the S. dispar Zone, M. rostratum Subzone at the top (following the zonal scheme of Owen, 1976).

The SPEETON CLAY FORMATION is, with only a few exceptions, complete for the entire Lower Cretaceous. Lamplugh (1889) divided it into four (A to D from the top down) on the basis of belemnites and the basal "coprolite Bed" was assigned to Bed E. This influenced later work and since that time a number of stratigraphical studies have been carried out, the most important being on the A Beds by Ennis (1937) and Kaye (1964), the B Beds by Kaye (1964), the C Beds by Fletcher (1969) and the D Beds by Neale (1960b, 1962a, 1968). The A (Minimus Marls and Ewaldi Beds) and B Beds, however, still remain only poorly understood as discussed by Rawson & Mutterlose (1983). Palaeontologically, the section has been given a great deal of attention and has consequently become a standard for the Early Cretaceous biostratigraphy for north western Europe.

The Speeton Clay of the type section is 101.95m thick, but borholes inland have proved thicknesses of up to 365m according to Dilley (in Neale, 1968). Lithologically it is a sequence of clays and shales of variable colour and carbonate content. Within this sequence, however, there are phosphatic horizons (eg. Bed E, the "Coprolite Bed" and D1, the "Compound nodular Bed"), nodules of limestone (eg. Bed D6H), cementstones (eg. the Middle B Beds or Cement Beds) and volcanic ash bands (eg. the Ryazanian D Beds of Knox & Fletcher, 1978; Lott et al., 1986). A detailed summary of the Speeton section is given by Neale (1974).

UPPER CRETACEOUS

A disconformity separates the Lower Cretaceous part of the FERRIBY CHALK FORMATION, the Hunstanton Chalk Member (and the Gault), from the Cenomanian part of the formation, which can also be divided into two:

2. Lower Chalk

1. The Cambridge Greensand.

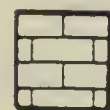
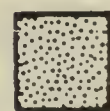
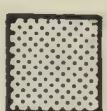
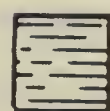
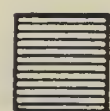
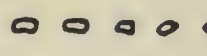
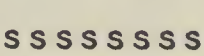
The CAMBRIDGE GREENSAND MEMBER accumulated after a period of erosion had removed the top of the Gault. The extent of the downcutting varies from locality to locality, but near Cambridge the top of the Gault is in the C. auritus Subzone (Bed 16 of the standard succession). It consists of a fine glauconitic, calcareous sand with phosphatic nodules and is rarely more than 0.3 to 0.6m thick, although Worssam & Taylor (1969) recorded thicknesses up to 1.5m in boreholes. Its age has been a matter of debate for over a century, but it would appear that in most areas it is Cenomanian in age (N. carcianense Subzone, M. mantelli Zone).

The Cambridge Greensand passes up into the LOWER CHALK, the lower part off which, forms the Chalk Marl, a sequence of bioturbated chalky marls and marly chalks (upper part of the M. mantelli Zone and basal A. rhotomagensis Zone). It is capped by the Burwell Rock (=Chilton Stone or Totternhoe Stone in southern England), a hard calcarenite with small phosphatic nodules and abundant Orbirhynchia mantelliana (Sowerby). The top boundary of the Burwell Rock forms the 'Mid Cenomanian non-sequence' of Carter & Hart (1977), above which the carbonate content increases and the Grey Chalk, a sequence of chalks and marls of T. acutus Subzone age, was deposited. A change in the microfaunas also takes place across this boundary, perhaps due to increased water depths.

The remainder of the Upper Cretaceous sequence will not be visited during the field excursion for three reasons: exposures are limited,

biostratigraphical control is poor and chalks of Yorkshire, are indurated so that extraction of Ostracoda is not possible.

KEY TO LITHOLOGIES
(for localities 1, 2, 5, 6, 7, 10)

	chalk/limestone		sandstone
	calcareenite		ironstone
	marl		oolitic ironstone
	mudstone/shale		grit
	siltstone		
	cementstone		phosphatic nodules
	calcareous nodules		shell bed
A	ammonite-rich horizons	BARR4	sample position

LOCALITY 1: BARRINGTON

The first locality on the itinerary is at Barrington, to the south east of Cambridge (National Grid Reference TL 398509). Here the Lower/Upper Cretaceous boundary can be seen. The Upper Gault (Albian), deposited in a shallow, marine environment, is overlain disconformably by the silty, glauconitic Cambridge Greensand (Cenomanian), which in turn passes up into the Lower Chalk.

THE UPPER GAULT

The Upper Gault (SAMPLE POSITION BARR1) is composed of pale grey, calcareous clay with occasional nodule beds and of Mortoniceras inflatum zonal age (probably Callihoplites auritus Subzone). A diverse fauna can be collected from the deposit including:

Macrocypis exquisita Kaye, Schuleridea jonesiana (Bosquet), Doloccytheridea (P.) bosquetiana (Jones & Hinde), Protocythere lineata striata Gruendel, Veenia barringtonensis Kaye, Mandocythere harrisiana (Jones), Cythereis luermanne hannoverana Bertram & Kemper, Cythereis (Cythereis) thoerenensis Triebel, Cornicythereis larivourensis (Damotte & Grosdidier), Cytherella ovata (Roemer), Cytherelloidea stricta (Jones & Hinde), Neocythere (Physocythere) steghausi (Mertens), N. (P.) semiconcentrica (Mertens), Neocythere (Neocythere) vanveenae Mertens, Planularia scrobicularis Weaver, Platycythereis gaultina (Jones) and P. chapmani Kaye.

Few species disappear from the record at the Albian/Cenomanian boundary, but Isocythereis fissicostis fissicostis Triebel, I. fortinodis reticulata Gruendel and Eucythere trigonalis (Jones & Hinde) appear to be

confined to the Gault. These species are, however, rather rare.

THE CAMBRIDGE GREENSAND

The Cambridge Greensand (SAMPLE POSITION BARR2) consists of about 1m of glauconitic sands with abundant phosphatic nodules. Its stratigraphical position has been a matter of debate for many years, but at this locality it is basal Cenomanian in age (M. mantelli Zone, the lower part of the N. carcitanense Subzone). Kaye (1964) systematically described some of the ostracods present at Barrington:

Bythoceratina (Bythoceratina) umbonata (Williamson), B. (Bythoceratina) bonnemai (Kaye), Monoceratina longispina (Bosquet), Cytherelloidea globosa Kaye and Platycythereis chapmani Kaye.

Other species that can be found are:

Cythereis (Cythereis) humilis humilis Weaver, Cythereis (Rehacythereis) bemerodensis Bertram & Kemper, 1971, Phthanoloxoconcha icknieldensis (Weaver) and many of the species present in the uppermost Gault of the area. Similar faunas elsewhere in Cambridgeshire and western Suffolk have been discussed by Wilkinson (in press). (The genus Phthanoloxoconcha is described by Wilkinson in the Shizuoka Symposium Volume). Care must be exercised in distinguishing reworked specimens from those present in situ.

THE CHALK

The Chalk Marl is about 28.5m thick at this site and capped by the Burwell Rock (=Totenhoe Stone). At its base it is somewhat silty, but this passes up into chalky marl which becomes a marly chalk in the upper 13m.

The base of chalky marl (SAMPLE LOCATION BARR3) falls within the M. mantelli Zone, M. saxbii subzone. It contains the last of the Albian species Bythoceratina (B.) bonnemai, Neocythere (Physocythere) steghausi

and Phthanoloxoconcha icknieldensis, but the other species extend through to the Burwell Rock:

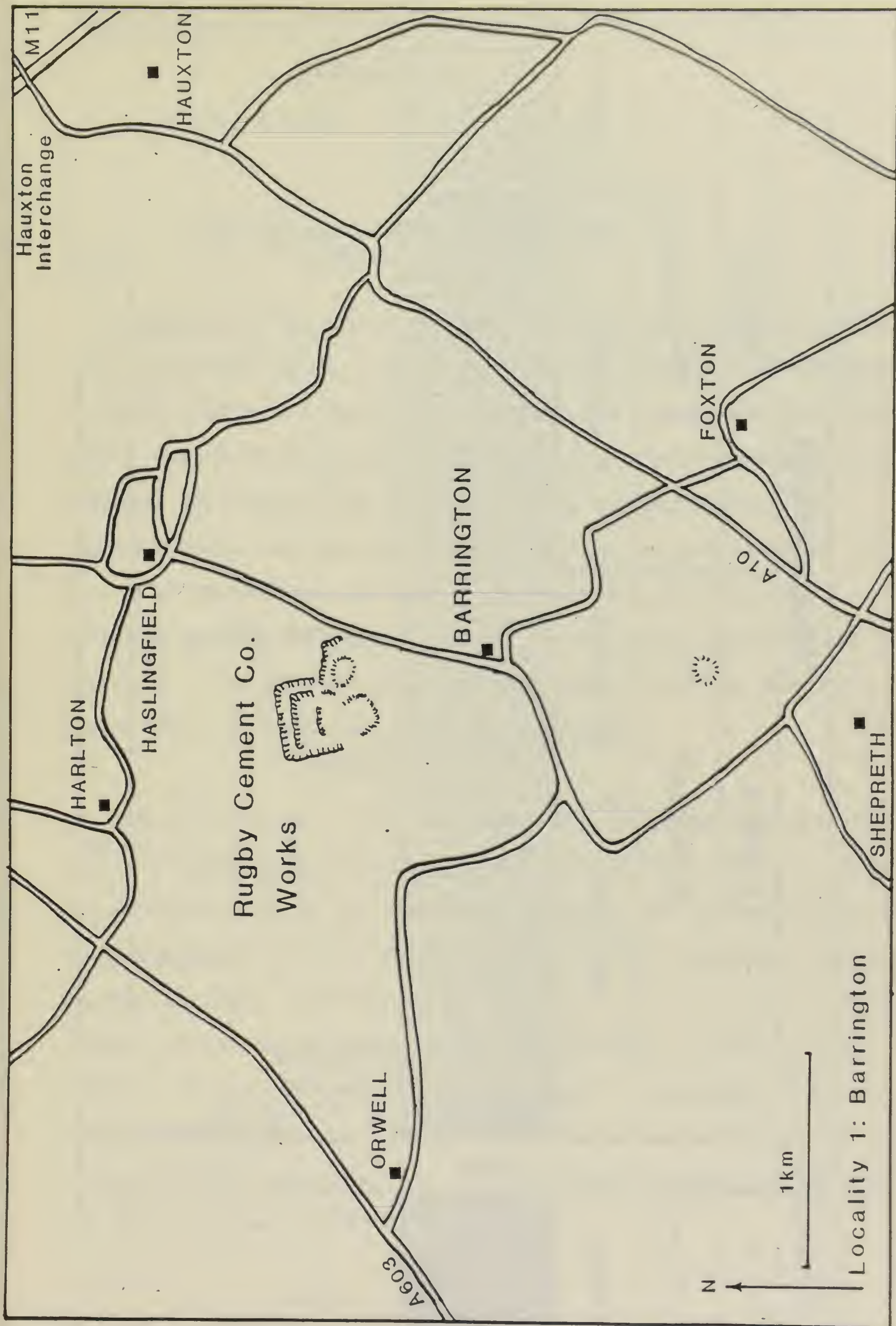
Cythereis (C.) humilis humilis, Cythereis (Rehacythereis) luermannae cf. hannoverana, Mandocythere harrisiana, Protocythere lineata striata, Schuleridea jonesiana, Cornicythere larivourensis, Neocythere (P.) semiconcentrica, N. (N.) vanveenae and Planileberis scrobicularis.

Within the marly chalk (A. rhotomagense Zone, T. costatus subzone)(SAMPLE POSITION BARR4), three species are added to the assemblage, Phthanoloxoconcha bluebellensis Weaver, Bairdoppilata southerhamensis Weaver and Bythoceratina (Bythoceratina) bluebellensis Weaver.

The Burwell rock (SAMPLE POSITION BARR5), a calcarenite with phosphatic nodules is also of T. acutus subzonal age. It contains a sparse fauna:

Cornicythereis larivourensis, ?Bairdoppilata southerhamensis, Phthanoloxoconcha bluebellensis and the first occurrences of Mandocythere inferangulata (Donze), Pontocyprrella robusta Weaver, Veenia ballonensis Damotte & Grosdidier, Oertliella alata Weaver and O. donzei Weaver.

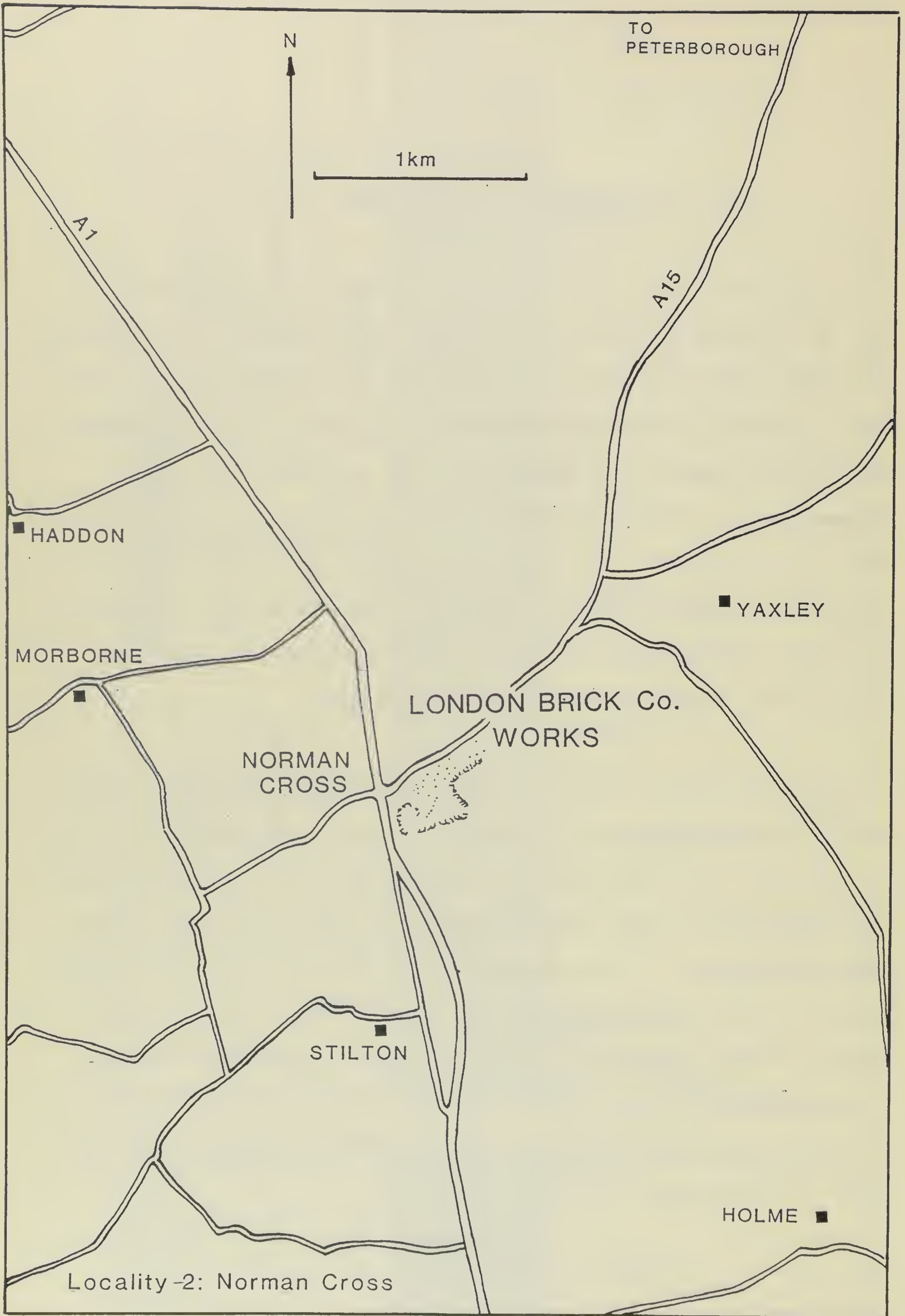
These species are again present at the base of the Grey Chalk (T. acutus Subzone) (SAMPLE POSITION BARR6).

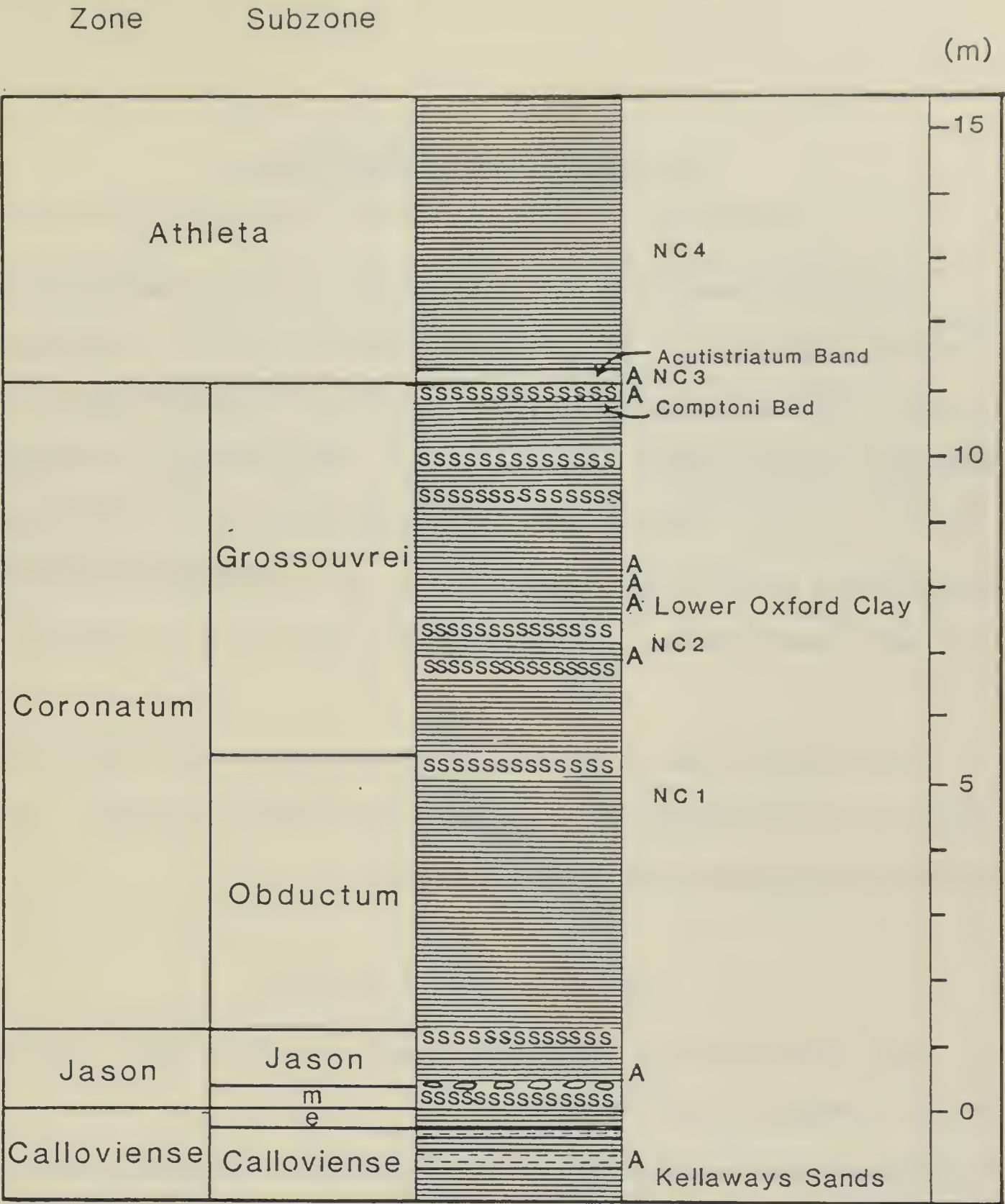


LOCALITY 2: NORMAN CROSS

Lying just to the east of the main A1 road at its junction with the A15, is the London Brick Co quarry at Norman Cross (National Grid Reference TL 162905-174916), the Yaxley Pit of Callomon (in Sylvester-Bradley & Ford, 1968). Here the olive-grey Kellaway Sands are overlain by the grey-green mudstones and shales of the Oxford Clay, some horizons of which are extremely shelly. The Base of the Oxford Clay can be placed into the latest part of the Jasoni Zone, but much of the sequence falls within the Coronatum Zone and the Athleta zone near the top of the quarry can also be collected. Although the foraminifera from the pit have been described (Medd, 1983), Ostracoda have not yet been published.

The Ostracoda fall within the Lophocythere interrupta Zone, but those species of Nophrecythere and Lophocythere normally associated with the zone are extremely rare. By far the most common taxon is an undescribed species of Pseudohutsonia closely resembling Whatley's (1965) manuscript species Hutsonia corallia. A taxon commonly found in the British Callovian is the strongly pitted species Praeschuleridea batei Whatley and this is also common at Norman Cross. Finally, Procytherura cf. tenuicosta Whatley, a species more commonly associated with the Oxfordian rather than Callovian, is found in small numbers and very rare specimens of Glabellacythere nuda may also be recovered.





m Medea
e Enodatum

Locality 2: Norman Cross

LOCALITY 3: KETTON CEMENT QUARRY

The Ketton Cement Quarry, situated close to the village of Ketton, (National Grid Reference SK 9720 0550) exposes not only a substantial section of the Lincolnshire Limestone, but also a complete section of the overlying Bathonian Upper Estuarine Series. Here, some 12m of non-marine clays with rootlet beds and thin brackish to marine clays are interbedded. Some horizons are rich in montmorillonite, derived from air-fall volcanic ash, and probably having its source in the North Sea area (Bradshaw, 1975).

The ostracod fauna of these beds has been described in Bate (1967) and belongs to the Strictocythere polonica Zone of Sheppard (1981). As such, these beds are basal Upper Bathonian in age.

THE UPPER ESTUARINE SERIES

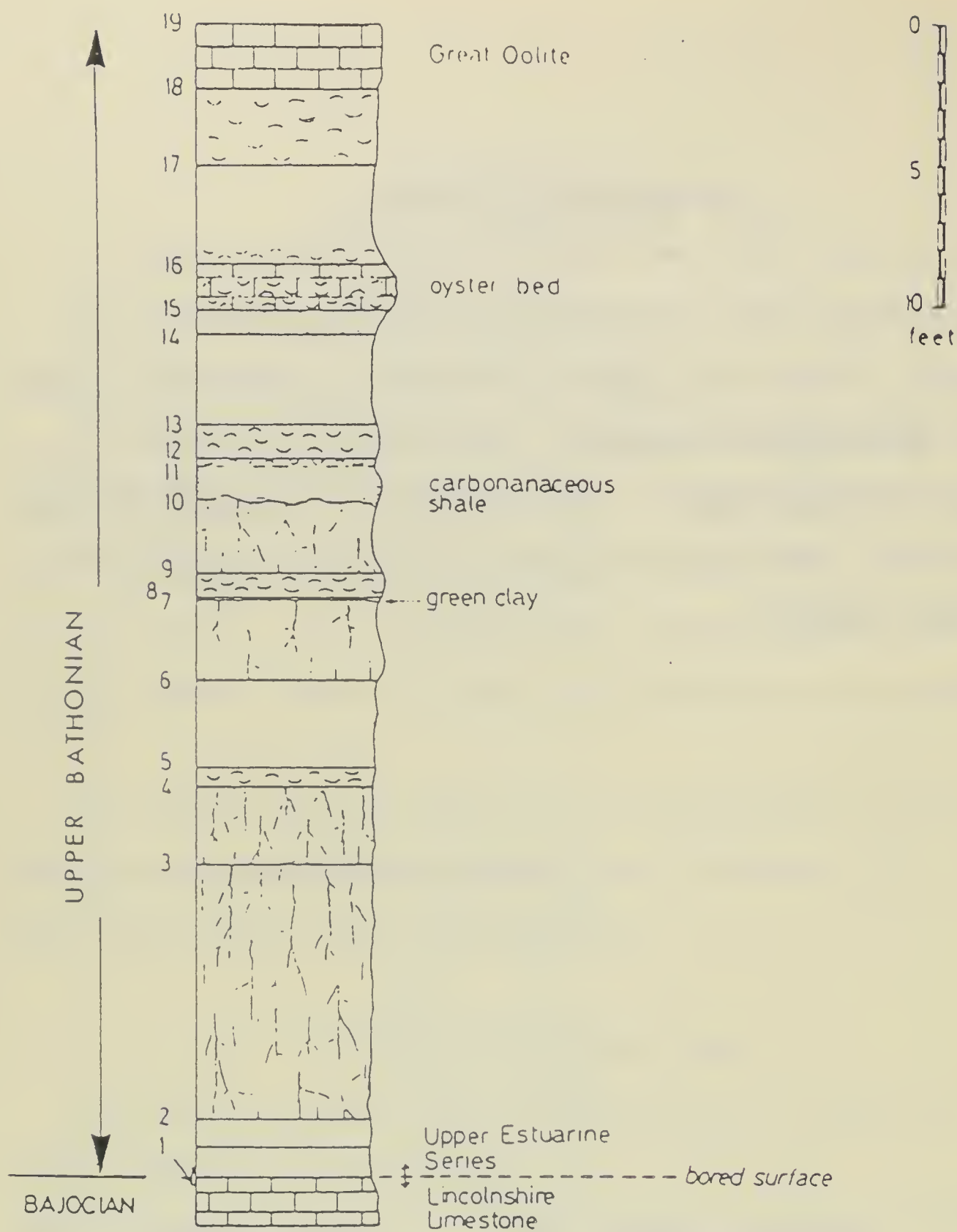
The richest ostracod faunas may be collected from beds 18-12, 9 and 5 and are composed of the following:

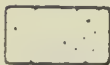
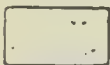
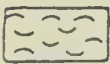
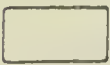
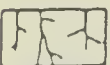
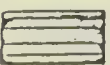
Belekocytheridea punctata Bate, Fastigatocythere juglandica (Jones), Galliaecytheridea? kingscliffensis Bate, Glyptocythere guembeliana (Jones), Lophocythere batei Malz, L. transversiplicata Bate, Macrodentina (Mediodentina) bathonica Bate, Marslatourella bullata Bate, Metacytheropteron drupaceum (Jones), Micropneumatocythere postrotunda Bate, M. quadrata Bate, M. subconcentrica (Jones), Paracypris terraefullonica (Jones & Sherborn), Praeschuleridea angulata (Plumhoff), Progonocythere levigata Bate, P. rugosa Bate, P. triquetra Bate and Schuleridea (Eoschuleridea) sp.

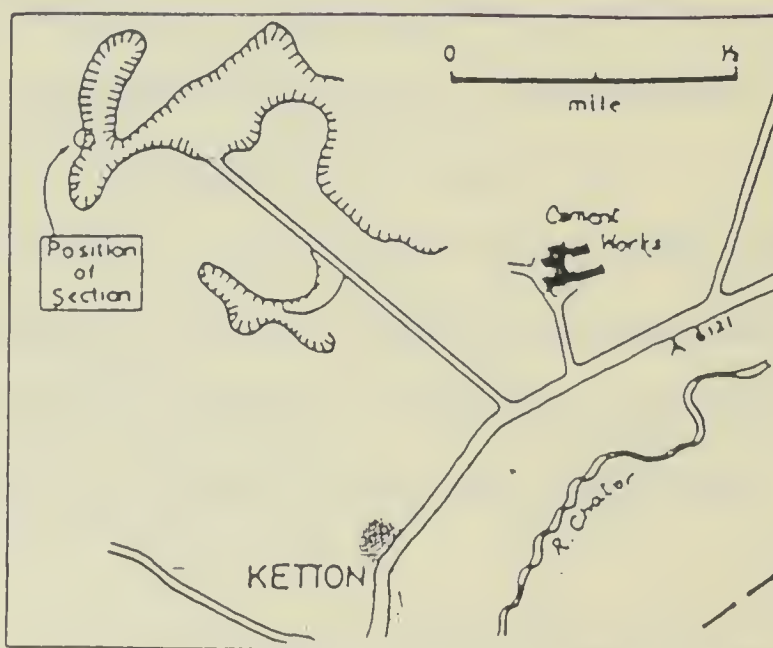
THE BLISWORTH LIMESTONE

Similar ostracod faunas can also be collected from the overlying Blisworth Limestone, which is only poorly developed in a series of old quarries nearby. However, the fauna is more marine and lacks such brackish ostracods as Belkocytheridea punctata. Also absent are the species of Macrodentina and Progonocythere. The appearance of Glyptocythere oscillum (Jones & Sherborn) identifies the incoming of the higher ostracod zone of Fossaterquemula blakeana.

Ketton Cement Works, Rutland.



-  sandy clay
-  banded clay & sand
-  shells
-  clay
-  limestone
-  clay, with plant roots
-  shale



LOCALITY 4: KIRTON IN LINDSEY

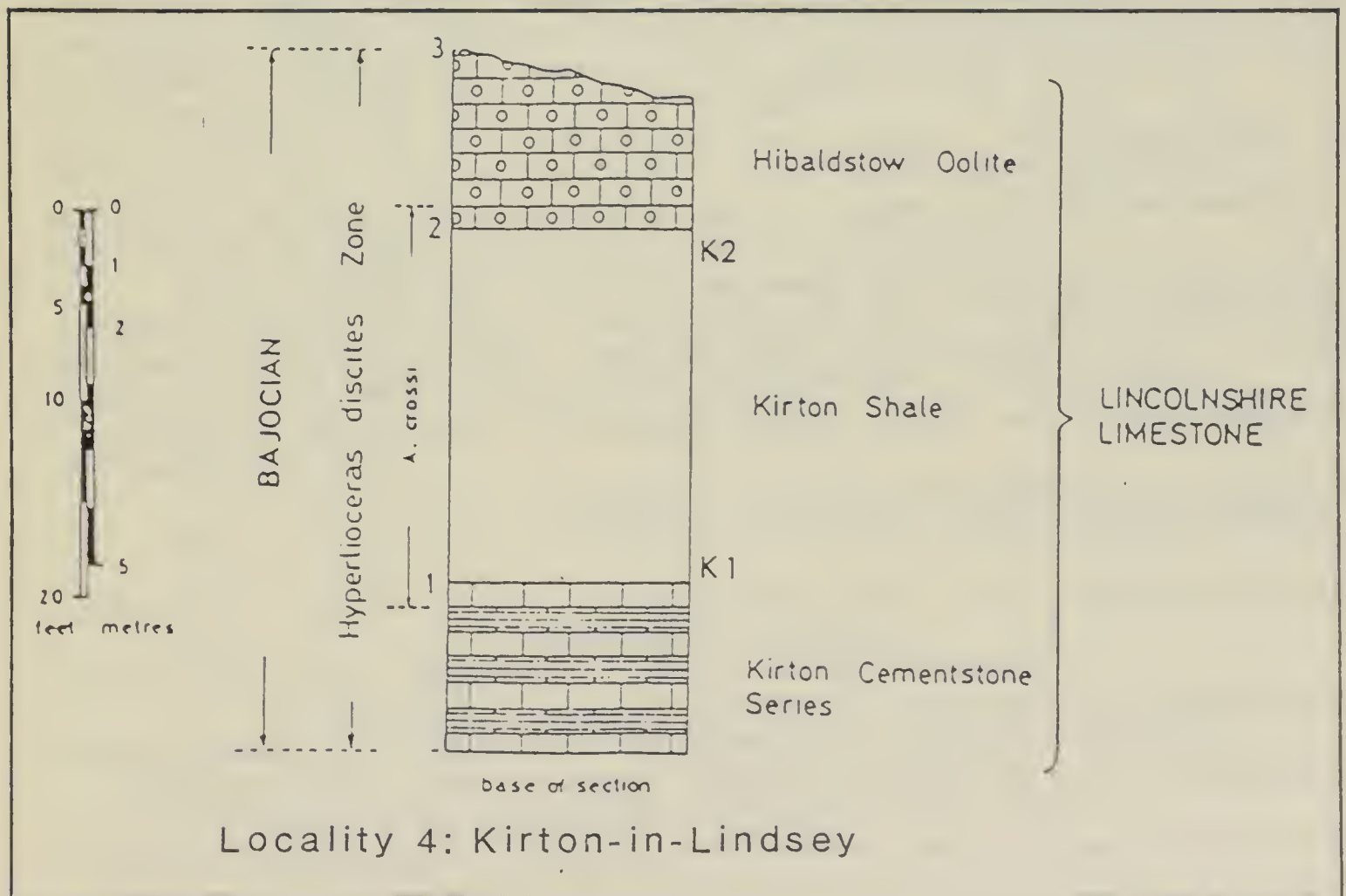
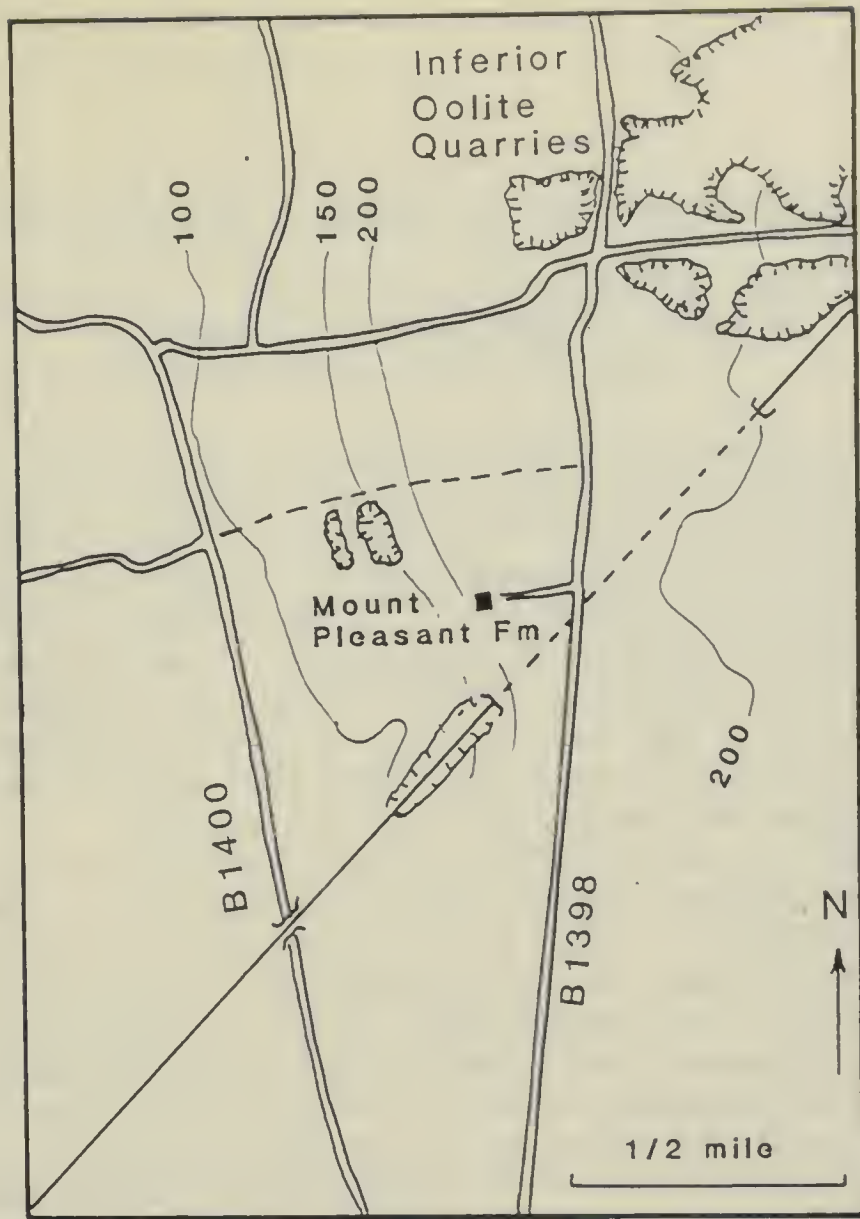
A large quarry situated to the east of the B1398 road, north of Lincoln (National Grid Reference SE 9428 0014) has cut into the cementstones and marls of the Lincolnshire Limestone. Isolated mounds on the quarry floor are Bajocian coral bioherms left after the removal of the clay facies. This entire section has been dated as Discites Zone age (Lowermost Bajocian).

THE KIRTON SHALE

The state of preservation of the ostracod faunas in the Kirton Shale is better than in the limestone facies; otherwise there is no difference in the faunas of the two. The following ostracods may be collected: Acanthocythere (Protoacanthocythere) faveolata Bate, Aulacocythere punctata Bate, A. reticulata Bate, Bairdia hilda Jones, Cytherella fullonica Jones & Sherborn, Cytherelloidea catenulata Jones & Sherborn, Cytheromorpha greetwellensis Bate, Dolococythere maculosa Bate, Ectyphocythere triangula (Brand), Fuhrbergiella (Praefuhrbergiella) arens Bate, Kirtonella plicata Bate, Monoceratina cf. scrobiculata Triebel & Bartenstein, M. vulsa Jones & Sherborn, Paracypris bajociana Bate, Platella jurassica Bate, Pleurocythere kirtonensis Bate, P. nodosa Bate, Praeschuleridea subtrigona (Jones & Sherborn) and Progonocythere cristata Bate.

The overlying Hibaldstow Oolite is equivalent to the Cave Oolite of Locality 9 and contains, like the underlying Kirton Cementstone Series, an

identical fauna as listed above.



LOCALITY 5: NETTLETON HILL QUARRY

At Nettleton Hill, northern Lincolnshire (National Grid Reference TF 109 995), the Claxby Formation (comprising 5.6m of Claxby Ironstone Member) disconformably overlies the Upper Jurassic part of the Spilsby Sandstone. It is Lower Valanginian at the base passing up into the Upper Valanginian, but the condensed nature of the deposit and the lack of macropalaeontological control makes subdivision difficult. The same problem exists in identifying the Valanginian/Hauterivian boundary, because the condensed "top calcareous beds" contain macrofaunal elements from both the Valanginian and early Hauterivian (E. amblygonium and E. noricum zones). The minette-type deposits were followed, after a short period of erosion that removed the E. regale Zone, by the Lower Tealby Clay Member of the Tealby Formation. At this locality, the basal c.4m is a mudstone with ferruginous ooliths that makes it difficult to separate from the underlying oolitic Claxby Ironstone. The upper part of the Lower Tealby Clay is, however, a finer mudstone that lacks ooliths. Bartenstein (1956) examined some Lower Tealby Clay (Hauterivian) species from the area and Wilkinson (in litt.) has examined the faunas of this pit.

CLAXBY IRONSTONE MEMBER

The basal part of the Claxby Ironstone comprises a pebbly grit approximately 0.41m in thickness (SAMPLE POSITION NHQ1). The ostracod fauna contains several rare undescribed species of cytherurids as well as: Protocythere hannoverana Bartenstein & Brand, Cytheropterina triebeli Neale, Mandelstamia sexti Neale and Schuleridea juddi Neale. A single,

poorly preserved carapace of Fabanella cf. boloniensis (Jones), a common element in the brackish and fresh-water Wealden deposits of southern England, has also recovered from the basal grit.

The basal grit passes up into 4.52m of ferruginous sands and oolitic ironstones. This interval is almost barren of ostracods, only very rare, poorly preserved, reworked early Valanginian specimens being present. However, the highest part of the Claxby Ironstone, the "Top Calcareous Beds", situated between 4.93 and 5.60m above the base of the Claxby Ironstone at this locality, are more fossiliferous. The following ostracods have been recovered from the base of this horizon (SAMPLE POSITION NHQ2) and can be dated to the E. amblygonium to E. noricum zones:

Pontocyprilla superba Neale, Hehticythere (Costacythere) frankei frankei (Triebel), Acrocythere hauteriviana (Bartenstein), Schuleridea thoerenensis werlensis Gruendel, Paracypris sinuata Neale, Eucytherura neocomiana Kaye and Stravia crossata Neale. A little higher, near the top of the 'Calcareous Beds', 5.15m above base of the Claxby Ironstone (SAMPLE POSITION NHQ3), several additional taxa can be found:

Cytherelloidea ovata Weber, Protocythere triplicata (Rocmer), Hehticythere (Hehticythere) hehti, Dolocythere longa Gruendel and Eucytherura nettletonensis Kaye.

Immediately below the phosphatic nodule bed (SAMPLE POSITION NHQ4) that defines the top of the "Top Calcareous Beds" (at 5.54m above the base of the member), the following are added to the assemblage:

Euryitycythere parisiorum Oertli, Cytherella exquisita Neale and undescribed species of Macrocypris are added to the fauna.

LOWER TEALBY CLAY MEMBER

The basal part of the Lower Tealby Clay (S. inversum Zone) comprises

oolitic, ferruginous mudstones (SAMPLE POSITION NHQ5) and is difficult to separate from the underlying oolitic ironstones. Cytherurids are particularly diverse 0.40m above the base of the member and include species of Cytheropteron, Metacytheropteron, Eucytherura, Paranotacythere and Hemicytherura. They are accompanied by:

Acrocythere hauteriviana (the morphotype 'laeva' is also present here), Cytherella exquisita, C. fragilis Neale, Cytherelloidea ovata, Schuleridea thoerenensis werlensis Gruendel, Dicrorygma (Dicrorygma) speetonensis Christensen, Quasihermanites bicarinata Gruendel, (?)Micrommatocythere sp. (= ?Bythoceratina cf. nescia of Neale, 1962), Paracypris cf. sinuata, Cytherelloidea ovata, Cythereis (Rehacythereis) senckenbergiana Triebel, Parexophthalmocythere rodewaldensis Klinger, Protocythere triplicata, Hehticythere (Hehticythere) hehti, H. (Costacythere) frankei frankei, Hemicytherura reticulosa (Chapmani), Eucytherura nettletonensis and E. neocomiana.

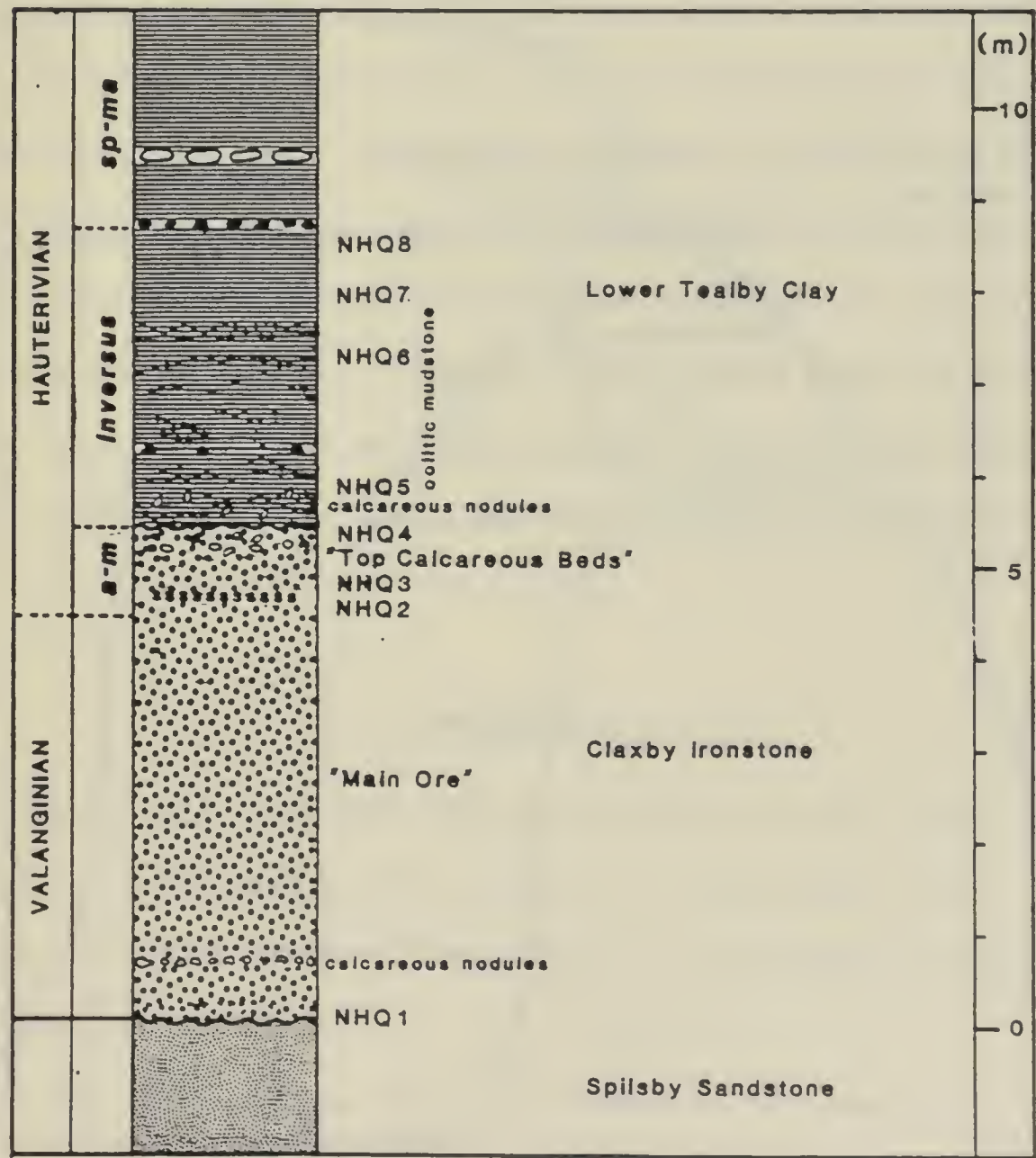
Faunas from 1.92 to 2.14m above the base of the Lower Tealby Clay (SAMPLE POSITION NHQ6) include several species in common with the earlier Hauterivian assemblages. Euryitycythere parisiorum is again present, but several species occur for the first time:

Schuleridea lamplughi Neale, Paranotacythere (Paranotacythere) anglica Neale, Neocythere (Physocythere) pustulosa Kaye and Amphicytherura bartensteini Kaye & Barker.

Smooth, non-oolitic mudstones then follow (SAMPLE POSITION NHQ7). The basal part, which is of S. inversus age, contains a diverse fauna: Acrocythere hauteriviana, Eucytherura neocomiana, E. nettletonensis, Hemicytherura reticulosa, Protocythere triplicata, Hehticythere (Hehticythere) hehti, H. (Costacythere) frankei frankei, Cytherelloidea ovata, Dolocythere longa, Parexophthalmocythere rodewaldensis, and

Quasihermanites bicarinata. Apatocythere ellipsoidea Triebel, A. simulans Triebel and Neocythere (Neocythere) protovanveenae Kaye all appear at the base of this facies.

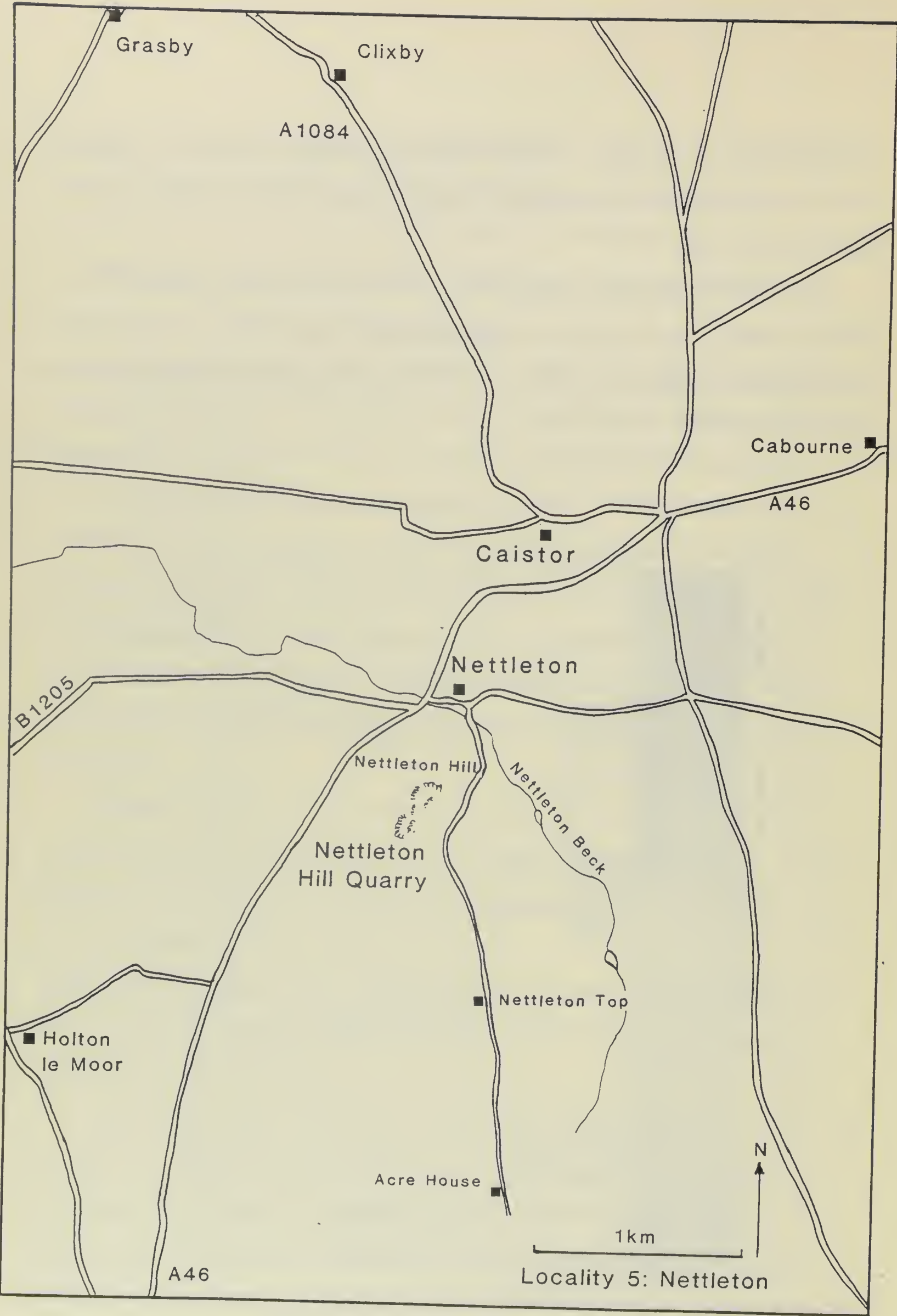
Most of these species are present 3.69m above the base (SAMPLE POSITION NHQ8), but in addition Cytherelloidea pulchra Neale, Amphicytherura roemeri (Bartenstein) and Paracytheridea problematica (Kaye) can also be found.



a-n amblygonium-noricus

sp-ma speetonensis-marginatus

Locality 5: Nettleton Hill Quarry



LOCALITY 6: SOUTH FERRIBY QUARRY

The sequence exposed at this locality (National Grid Reference TA 9915 2045) straddles the Oxfordian/Kimmeridgian boundary where the Ampthill Clay is overlain disconformably by the Kimmeridge Clay (Cox, in Smart & Wood, 1976). Most of the latter formation has been removed by erosion, however, and the overstepping Lower Albian Carstone (0.65m thick) forms a conspicuous facies change in the quarry. This arenaceous deposit passes up into the thickest recorded development of the Hunstanton Chalk in northern Lincolnshire and South Humberside, reaching a thickness of c. 3m. Morter (in press) takes this as the standard section and recognises 11 beds. The ostracods from the Oxfordian and Kimmeridgian part of the sequence have recently been described by Ahmed (1987). Those from the Hunstanton Chalk Member have been summarised by Wilkinson (in Gaunt, Fletcher & Wood, in press) and the Ostracod zonal scheme for the Gault (Wilkinson & Morter, 1981) can be applied.

THE AMPTHILL CLAY

The Oxfordian Ampthill Clay, consisting of grey clays with occasional nodule horizons, extends from the floor of the quarry up to c. 7.5m below the base of the Carstone. The presence of the ammonite *Ringsteadia* proves the Pseudocordata Zone.

Approximately 18.5m below the Carstone is a conspicuous layer of calcareous concretions. Approximately 1m below this bed (SAMPLE POSITION SF1) the following fauna can be collected:

Cytherella sp., Eripleura eleanorae Wilkinson, Galliaecytheridea dissimilis

Oertli, G. postrotunda Oertli, G. dorsetensis Christensen & Kilenyi and Schulerideatriebeli Steghaus.

A similar fauna can be collected at the top of the Ampthill Clay, about 9m below the base of the Carstone (SAMPLE POSITION SF2) at which level Macrodentina (Polydentina) parva Ahmed and M. (P.) ferribyensis Ahmed also occur.

THE KIMMERIDGE CLAY

The base of the Kimmeridge Clay is at the "Oxytoma Cementsone" approximately 7.5m below the base of the Carstone, the calcareous nodules forming a prominent feature in the quarry. This bed is rich in the bivalves Oxtoma, Camptonectes, oysters and fragments of a perisphinctid ammonite. The remainder of the formation consists of grey clay with three thin ferruginous siltstones at 3.5, 4.3 and 5.2m below the Carstone. The presence of the ammonite Pictonia in the lower 4.0m (SAMPLE POSITION SF3) is indicative of the Baylei Zone, whereas the occurrence of Rasenia in the upper 3.5m (SAMPLE POSITION SF4) proves the presence of the Cymodoce Zone.

Ostracoda at SAMPLE POSITION SF3, c. 1m above the base of the formation, include:

Galliaecytheridea dissimilis (abundant), Eripleura eleanorae and Schuleridea triebeli (common), together with rare Galliaecytheridea postrotunda, G. dorsetensis, Paranotacythere (Unicosta) extendata Bassiouni, Klentnicella rodewaldensis (Klingler) and Cytherella sp.

Approximately 1.5m above the highest of the three ferruginous siltstones (and c. 2.0m below the base of the Carstone) (SAMPLE POSITION SF4), the following can be found:

Schuleridea triebeli (common), Galliaecytheridea dissimilis (common), G. dorsetensis, Macrodentina (Macrodentina) cicatricosa Malz and M. (M.)

maculata (sensu Kilenyi, 1969, non Malz, 1958).

THE CARSTONE

The Carstone comprises dark brown, ferruginous sands SAMPLE POSITION SF5) that contain the brachiopod Burrirhynchia leightonensis and the bivalve Neithea aff. quinquecostata about 15cm from the top, indicating the D. mammillatum Zone (A.A. Morter, personal communication). Ostracoda have yet to be found at this locality, although elsewhere very rare specimens of Mandocythere harrisiana and Neocythere (Physocythere) lingenensis Mertens have been found.

THE HUNSTANTON CHALK

The Carstone passes up into the Hunstanton Chalk Member through about 0.15m of red-brown sandy marl with common Neohibolites minimus (Bed 1 of Morter, in press). It lacks Ostracoda, but Bed 2 (SAMPLE POSITION SF6), a pale red, silty chalk with Birostrina concentrica and N. minimus contains the following, indicative of the albae/bosquetiana concurrent range zone: Cytherella ovata (abundant), C. "parallela", Cytherelloidea knaptonensis, Cythereis (Cythereis) reticulata Jones & Hinde, Protocythere albae Damotte & Grosdidier, Doloccytheridea (Puracytheridea) bosquetiana, Mandocythere harrisiana, Neocythere ventrocostata Gruendel, Cornicythereis bonnema Triebel and Schuleridea jonesiana.

Bed 3 is a dark red-brown marl with chalk cobbles and phosphatic nodules in the basal and middle parts. The basal cobbles contained Middle Albian Birostrina concentrica, but those in the middle part of the bed contained Upper Albian Birostrina sulcata of D. cristatum Subzonal age (Morter, in press, personal communication). The Ostracoda from the marl surrounding the mid-bed cobbles (SAMPLE POSITION SF7) are extremely rare

and poorly preserved. However, the following can be recognised:

Protocythere lineata striata, Cytherella ovata, Mandocythere harrisiana and Schuleridea jonesiana.

Bed 4 (SAMPLE POSITION SF8), a pale brick-red chalk, with common Birostrina sulcata (H. orbignyi Subzone) contains:

Cytherella ovata (dominant), Mandocythere harrisiana, Neocythere (Physocythere) steghausi, Protocythere lineata striata, Cytherella "parallela", Cythereis (Rehacythereis) luermannae luermannae, Saxocythere notera senilis, Schuleridea dimorphica and Neocythere (Neocythere) vanveenae.

Ostracoda are extremely rare in the next three beds. Bed 5, a brick-red marl, green at the top, with common inoceramid debris, contains only very rare specimens of Mandocythere harrisiana. Bed 6, a hard, pyritic, yellow chalk with inoceramid fragments, proves little better with very rare Protocythere lineata striata and Cytherella ovata. The occurrence of Neohibolites oxycaudatus and the common Birostrina sulcata indicates the presence of the H. orbignyi Subzone, whereas the absence of the latter in Bed 6 is consistent with the H. varicosum Subzone (A Morter, personal communication). The brick-red, marly chalk of Bed 7 contains a flood of Neohibolites, diagnostic of the higher part of the H. varicosum Subzone. Rare specimens of Mandocythere harrisiana, Schuleridea jonesiana and Protocythere lineata striata can be found at this level.

Bed 8 of the Hunstanton Chalk Member can be recognised by means of the sudden influx of abundant Inoceramus lissa, although the presence of Neohibolites at the base suggests that the H. varicosum/C. auritus subzonal boundary falls within the lower part of the bed (A.A. Morter, personal communication). The ostracod assemblage in this yellow chalk (SAMPLE POSITION SF9) is diverse, 20 species are present although specimens are not

particularly common:

Cytherella ovata (abundant); Protocythere lineata striata, Cytherella "parallela" and Neocythere (Physocythere) steghausi (common), and the remaining species are rare Mandocythere harrisiana, Cythereis (Rehacythereis) luermannae luermannae, C. (Rehacythereis) luermannae hannoverana, Isocythereis fissicostis gracilis, Neocythere (Physocythere) semilaeva, N. (Neocythere) vanveenae, N. (Centrocythere) denticulata, Bythoceratina (Bythoceratina) umbonata umbonata, Monoceratina longispina, Cornicythereis bonnemaï, C. larivourensis, Schuleridea jonesiana, Cytherelloidea knaptonensis, C. stricta, Macrocypris exquisita and Platycythereis gaultina. The thin (0.03-0.04m) red marl which constitutes Bed 9 is barren Ostracoda, but the recovery of Biplicatoria hunstantonensis may indicate that it is a lateral equivalence of the Milton Brachiopod Bed, which is recognised in the C. auritus Gault of East Anglia (A.A. Morter, personal communication). However, the massive, brick-red, hard chalk with common Neohibolites and smooth Aucellina that constitute Bed 10, yields a large population in the upper part (SAMPLE POSITION SF10): Cytherella ovata (abundant), C. "parallela", Cythereis (Rehacythereis) luermannae hannoverana, C. (R.) paranuda Weaver, Neocythere (Physocythere) steghausi, N. (P.) semilaeva Kaye, Protocythere lineata striata, Bythoceratina (Bythoceratina) umbonata, Cornicythereis larivourensis, Pontocyprrella harrisiana and Macrocypris exquisita.

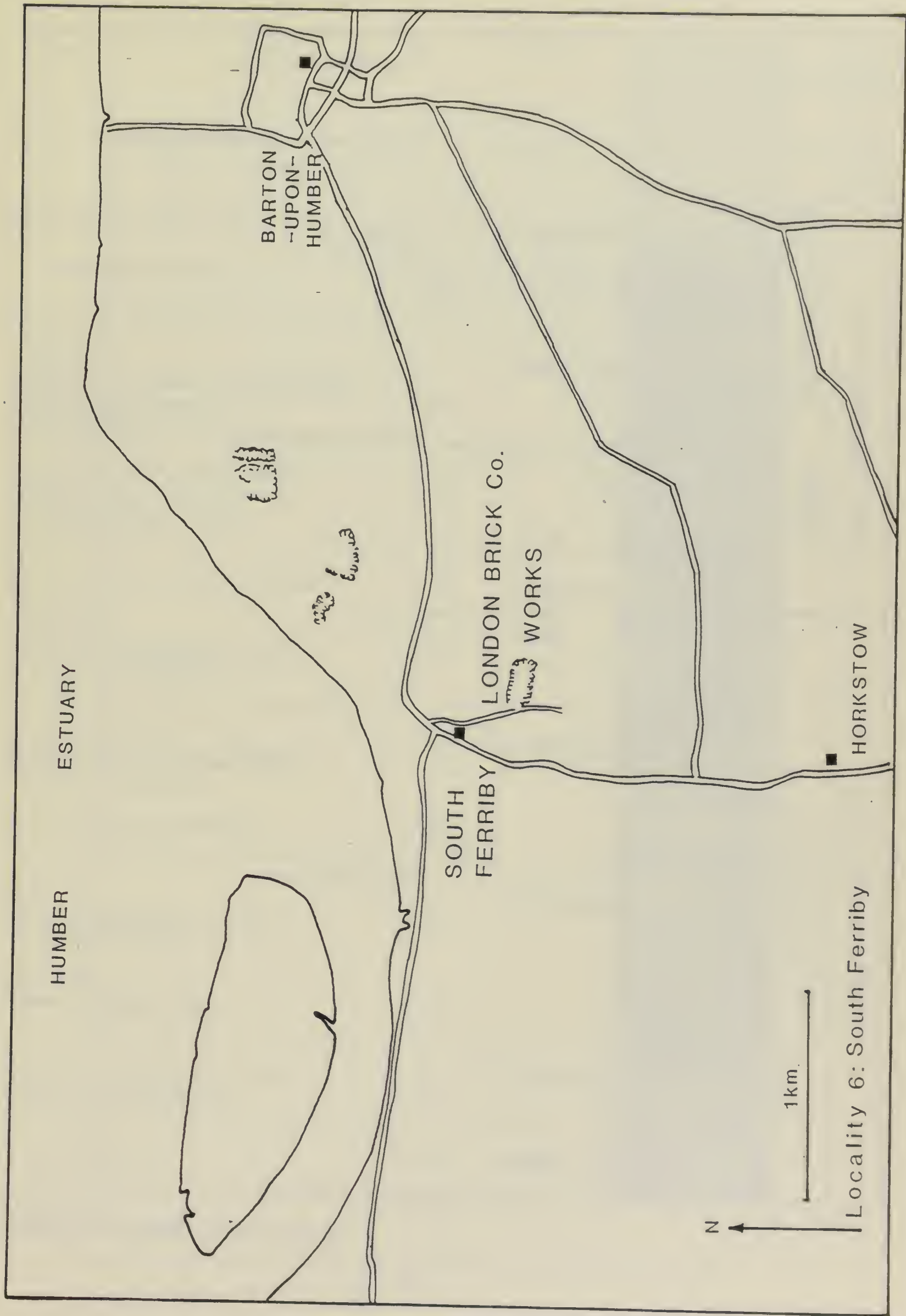
The sample from Bed 11 (SAMPLE POSITION SF11), a massive, hard chalk with abundant Aucellina, Neohibolites and, in the upper part, Thalassinoides burrows, contains an almost identical ostracod population as that in Bed 10 together with:

Cytherelloidea kayei Weaver, Mandocythere harrisiana, Cornicythereis bonnemaï and Isocythereis fissicostis gracilis Gruendel.

THE PARADOXICA BED

The Paradoxica Bed (Belchford Member sensu Jeans 1980) disconformably overlies the Hunstanton Chalk Member. The top of the Albian is marked by an erosion surface that is overlain by 0.002m of red marl, which, elsewhere in the southern North Sea area, expands in thickness and contains Cenomanian species of Aucellina and Neohibolites ultimus (C. Wood, personal communication). The following Ostracoda can be collected from the Paradoxica Bed (SAMPLE POSITION SF12):

Abundant Neocythere (Physocythere) steghausi, Protocythere lineata striata and Cytherella ovata, together with less common C. "parallela", Cytherelloidea stricta Jones & Hinde, Pontocyprrella harrisiana, Schuleridea jonesiana, Polycope nuda Kaye, Cythereis (Rehacythereis) luermannae hannoverana, Neocythere (Physocythere) steghausi (in the lower part of the Bed), Mandocythereis harrisiana and Cornicythereis bonnemai.



Locality 6: South Ferriby

THE HUNSTANTON CHALK MEMBER ("RED CHALK") AT SOUTH FERRIBY

Bed No.	Bed characteristics	Thickness (m)	Macrofaunal subzones	Sample points
11	Limestone. <u>Aucellina</u> present; <u>Neohibolites praeultimus</u> common; <u>Thalassiodites</u> at the top	0.50	<u>M. rostratum</u>	SF11
10	Limestone with marly whisps. <u>Neohibolites</u> , including <u>N. praeultimus</u> , common	0.70		SF10
9	Thin marl with chalk pebbles.	0.03	<u>C. auritus</u>	
8	Limestone. Abundant <u>Inoceramus</u> prisms including <u>I. lissa</u>	0.30		SF9
7	Marly Limestone. <u>Neohibolites</u> and <u>Inoceramus</u> fragments abundant	0.24	<u>H. varicosum</u>	
6	Hard pyritous Limestone.	0.20		
5	Marl. Common <u>Birostrina sulcata</u> and <u>Neohibolites</u>	0.15	<u>H. orbigny</u>	
4	Limestone. Common <u>Neohibolites</u>	0.13		SF8
3	Marl with limestone cobbles. Abundant <u>Neohibolites</u>	0.20	<u>D. cristatum</u>	SF7
2	Silty limestone	0.30	Middle Albian	SF6
1	Sandy marl <u>Neohibolites</u> common	0.15		

LOCALITY 7: REIGHTON BAY, SPEETON

At Reighton Gap (National Grid Reference TA 147 759), the Kimmeridge Clay / Speeton Clay Boundary can be observed below the "Coprolite Bed" (Bed E), the latter representing most of the early Ryazanian. The succeeding Speeton Clay then extends 1.5km along the beach to Speeton Cliff (National Grid Reference TA158 753), which comprises Hunstanton Chalk ("Red Chalk" of many authors) at the base and Cenomanian white Chalk, with occasional pink bands, above. The lithology and stratigraphy of this section is summarised by Neale (1974).

Speeton Clay ostracods have been published in a series of papers by Neale and Kaye (see Neale, 1978 for a reference list). Kimmeridgian and Cenomanian ostracods have not been published, indeed the highest part of the Kimmeridge Clay (Pectinatus Zone) (SAMPLE POSITION SP1) exposed on the beach section has not yielded ostracods so far.

BEDS D8-D6: RYAZANIAN

Immediately overlying the basal phosphatic nodules of the "Coprolite Bed" are black shales (D8) and banded clays (D7) that were deposited in low oxygenated conditions. They are generally barren of Ostracoda, although rare specimens of Mandelstamia (Mandelstamia) sexti Neale have occasionally been found in D7C (Neale, 1962).

The Blue Beds (D6) (SAMPLE POSITION SP2) accumulated in well aerated conditions during the P. albidum Zone and the following fauna can be found: Mandocythere (Mandelstamia) sexti, Paranotacythere (Paranotacythere) speetonensis (Neale), Schuleridea juddi Neale, Galliaecytheridea teres

(Neale), Paracypris caerulea Neale, Cytheropterina triebeli Neale and Pontocypris felix Neale.

BEDS D5-D2E: VALANGINIAN

The stratigraphical position of the Lingula Bed (the dark brown laminated mudstone comprising Bed D5) is problematical, having been assigned to both the Ryazanian and Valanginian in the past. This bed, together with much of the succeeding grey-brown mudstones of the Astarte Beds (D4), was deposited in poorly oxygenated, perhaps brackish lagoonal, conditions and is devoid of Ostracoda. However, a fauna can be recovered from the upper part of D4 (SAMPLE POSITION SP3):

Paranotacythere (Paranotacythere) reticulata Neale, P. (P.) globosa Neale, Protocythere hannoverana Bartenstein & Brand, Cytheropterina eboracica Neale, Schuleridea praethoerenensis Bartenstein & Brand, Paracypris parallela Neale, Stravia crossata Neale and Doloccytheridea wolburgi Bartenstein & Brand.

Neale (1962) recovered specimens of Stillina acuminata Neale from the brown, sideritic mudstones of Bed D3. This species, together with the above Valanginian fauna, can be found in the base of the brown pyritic clays of Bed D2 (SAMPLE POSITION SP4).

BEDS D2D-D1: HAUTERIVIAN

The highest D Beds, the Compound Nodule Bed (D1) and a dark glauconitic mudstone (D2D) fall within the basal Hauterivian (E. noricum and E. amblygonium zones respectively). A diagnostic fauna can be collected from the base of Bed D2 (SAMPLE POSITION SP5) although many taxa are rare:

Euryitycythere parisiorum Oertli, Cytherella exquisita Neale, C. fragilis

Neale, Cytherelloidea ovata Weber, Exopthalmocythere anterospinosa Neale, Hehticythere hehti, H.(Costacythere) frankei frankei (Triebel), Protocythere triplicata (Roemer), Acrocythere hauteriviana (Bartenstein), Paranotacythere (Paranotacythere) diglypta diglypta Triebel, Paracypris sinuata Neale, Schuleridea lamplughi Neale and Apatocythere spinosa Neale.

A little above the base of the Hauterivian (SAMPLE POSITION SP6), and just below the Compound Nodule Bed (D1), the above fauna was accompanied by:

Cythereis (Rehacythereis) senckenbergi Triebel, Bythoceratina bispinosa (Weber), Parexopthalmocythere rodewaldensis Bartenstein & Brand, Doloccytheridea reightonensis Neale and Pontocyprrella superba Neale.

BEDS C2D-C11: MIDDLE AND UPPER HATERIVIAN

Beds C8-C11 are of E. regale age. The grey mudstones just above the Compound Nodule Bed (Beds C10-C11) (SAMPLE POSITION SP7), contain several species that range up from the preceding zone, including:

Protocythere triplicata, Hehticythere (Hehticythere) hehti, Acrocythere hauteriviana, Paranotacythere (Paranotacythere) diglypta diglypta, Paracypris sinuata and Schulerida lamplughi.

Two further species make their appearance here: Schuleridea wendensis and Doloccytheridea (Doloccytheridea)hilseana (Roemer).

At the top of the E. regale Zone, the dark grey, pyritic mudstones of Bed C8, and the lower part of the succeeding grey, glauconitic mudstones that comprise Bed 7 (S. inversus Zone) (SAMPLE POSITION SP8) a somewhat reduced fauna may be recovered including:

Protocythere triplicata, Hehticythere (Hehticythere) hehti, H. (Costacythere) frankei cf. fordenensis, Acrocythere hauteriviana, Schuleridea wendensis and Doloccytheridea (Puracytheridea) intermedia

Oertli.

The S. speetonensis Zone, Beds C5-C6 (dark grey mudstones with brown phosphatic nodules) are barren of Ostracoda, but the grey glauconitic mudstone of Bed C4B, S. gottschei Zone (SAMPLE POSITION SP9), contains a good fauna:

Cytherelloidea ovata, C. pulchra, Apatocythere ellipsoidea, A. simulans, Schuleridea bilobata, Doloccytheridea (Puracytheridea) intermedia, Dicrorygma (Dicrorygma) minuta(Kaye), Protocythere triplicata, Hehticythere (Hehticythere) hehti, Acrocythere hauteriviana, Neocythere (Neocythere) protovanveenae Kaye, Eucytherura neocomiana, Infracytheropteron exquisita and Pseudomacrocythere parva (Kaye).

The S. marginatus Zone, Beds C2D-C3 (SAMPLE POSITION SP10), contains a similar fauna to that in the S. gottschei Zone, but Schuleridea rhomboidalis and Paranotacythere (Paranotacythere) inversa costata are also included.

BEDS C2C-LOWER B: LOWER BARREMIAN

The upper part of the C Beds (C2C-C1) and the lowest part of the Lower B Beds (LB5-6) are basal Barremian and have been dated to the S. variabilis Zone. They consist of grey, usually glauconitic mudstones with nodules at the base. Ostracoda that have been found abundantly at this level (SAMPLE POSITION SP11) are:

Doloccytheridea (Puracytheridea) neali, Acrocythere hauteriviana, Protocythere triplicata, Apatocythere simulans and Schuleridea bilobata.

However a number of less common taxa can also be recovered:

Paracypris sinuata Neale, Pseudomacrocypris parva, Pontocyprrella mandelstami Kaye, Dicrorygma (Dicrorygma) minuta, Paranotacythere (Paranotacythere) inversa inversa (Cornuel), Hehticythere (Hehticythere)

hechti, Cytherella speetonensis, Cytherelloidea pulchra, Apatocythere ellipsoidea, Chapmanicytherura nuda (Kaye), Eocytheropteron nova (Kaye), Cytheropteron reightonensis, Infracytheropteron exquisita (Kaye), Paranotacythere (Paranotacythere) blanda and Parexophthalmocythere rodewaldensis.

Many of the above are either very rare or absent above the base of the Lower B Beds, but in the lower part of the P. rarocinctum Zone (the dark grey, shelly, pyritic mudstone of LB4) a diverse fauna can be collected (SAMPLE POSITION SP12):

Schuleridea bilobata (Triebel), S. rhomboidalis Neale, Doloccytheridea (Puracytheridea) neali, Protocythere triplicata, Apatocythere simulans, A. ellipsoidea, Paranotacythere (Paranotacythere) inversa inversa, P. (P.) blanda, Acrocythere hauteriviana, Neocythere (Neocythere) protovanveenae, Paracypris sinuata and Eocytheropteron nova.

The upper part of the Lower B Beds (LB1-2) are frequently barren of Ostracoda, although Doloccytheridea (Puracytheridea) intermedia may be found occasionally, but the basal part of the Cement Beds are devoid of ostracods. Unfortunately, the fossiliferous upper part of the Cement Beds and Upper B Beds, together with the Ewaldi Beds and Minimus Marls (ie. Upper Barremian to Middle Albian) are not visible due to slumping of the cliffs.

HUNSTANTON CHALK

The Hunstanton Chalk (ie. the "Red Chalk" of many authors) can be sampled at the foot of the Speeton Cliffs at the south end of Speeton Sands. According to Neale (1974) and Rawson et al. (1978) they date to the Upper Albian and basal Cenomanian, and are thus younger than in Lincolnshire and East Anglia. The ostracod fauna at the base of the

deposit (SAMPLE POSITION SP13) is as follows:

Cytherella ovata, C. "parallela", Cytherelloidea stricta, Schuleridea jonesiana, Habrocythere fragilis, Cornicythereis bonnemai, Cythereis (Cythereis) hirsuta, C. (C.) thoerenensis, C. (Rehacythereis) glabrella, Protocythere lineata striata, Mandocythere harrisiana, Neocythere (Neocythere) vanveenae, N. (Centrocythere) denticulata, Neocythere (Physocythere) steghausi, N. (P.) semilaeva and Isocythereis fissicostis.

The upper part of the "Red Chalk" (SAMPLE POSITION SP14) is less diverse, but the following can be collected:

Cytherella ovata, C. "parallela", Cytherelloidea stricta, Doloccythere bosquetiana, Cornicythereis bonnemai, Protocythere lineata striata, Mandocythere harrisiana, I. fortinodis, Neocythere (Neocythere) vanveenae and N. (Physocythere) semiconcentrica.

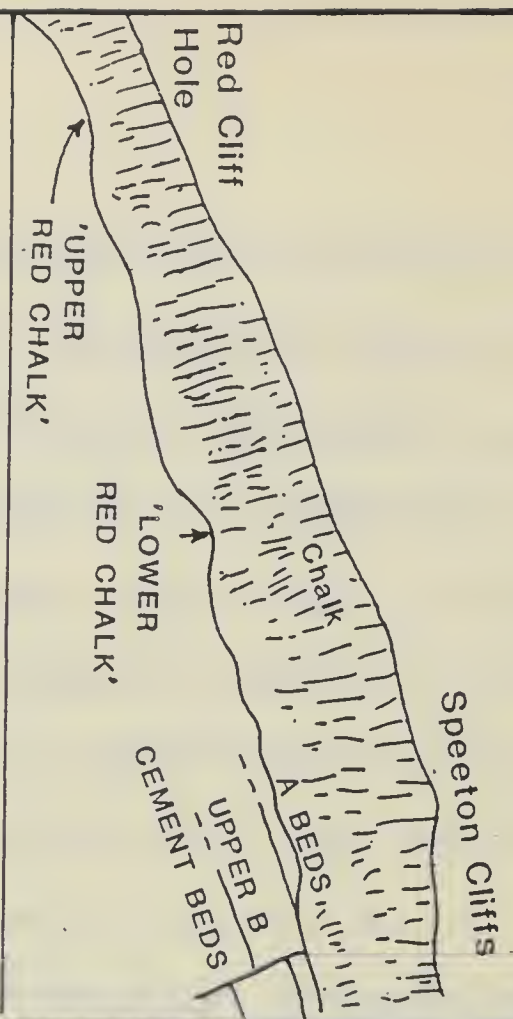
The Grey Band, at the top of the Albian (SAMPLE POSITION SP15), is composed of hard grey chalk, with Neohibolites minimus, situated between the "Lower" and "Upper" Red Chalk. A sparse fauna may be collected here including:

Cytherella ovata, C. "parallela", Bythoceratina (Bythoceratina) umbonata, B. (Cuneoceratina) herrigi, Mandocythere harrisiana, Cornicythereis larivourensis, Neocythere (Physocythere) steghaus and Planileberis scrobicularis.

The "Upper Red Chalk" (SAMPLE LOCALITY 16) lacks Neohibolites minimus and is placed in the basal Cenomanian. Ostracods are rare, but the following can be found;

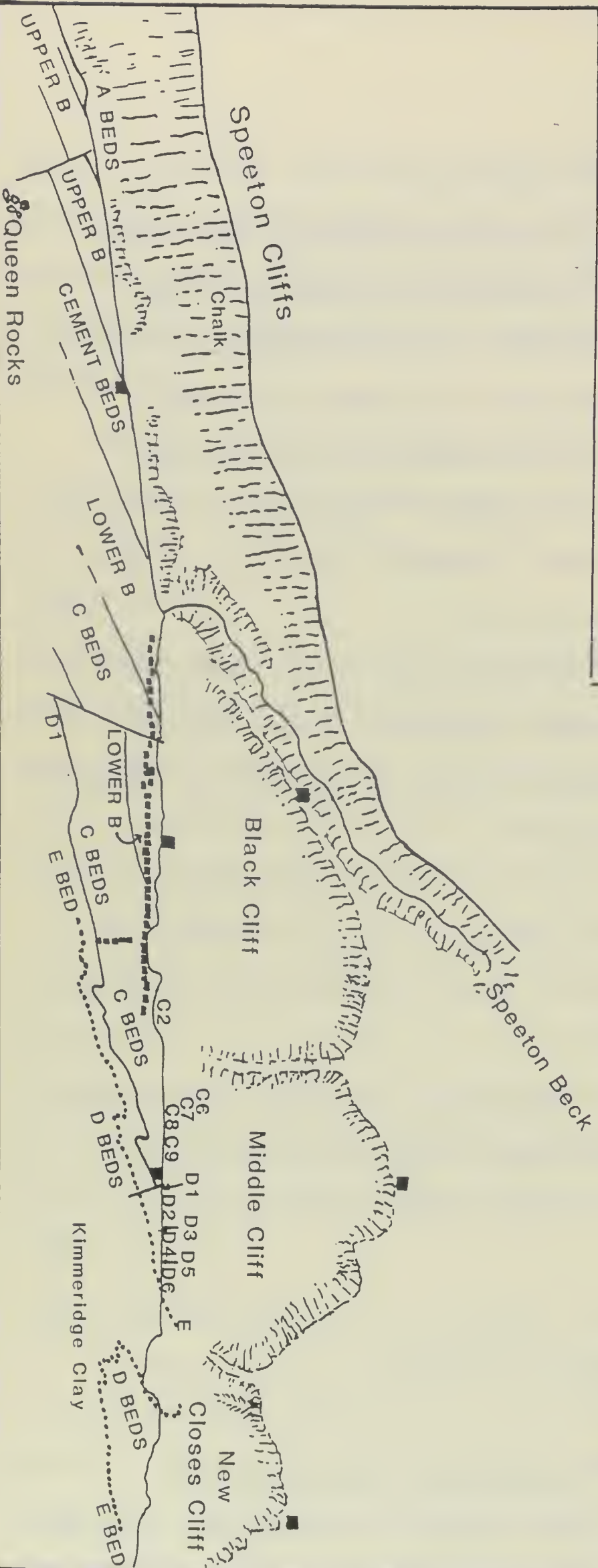
Polycope nuda, Cytherella ovata, Doloccytheridea (Puracytheridea) bosquetiana, Mandocythere harrisiana, Neocythere (Physocythere) steghausi, N. (P.) semilaeva and Cornicythereis larivourensis.

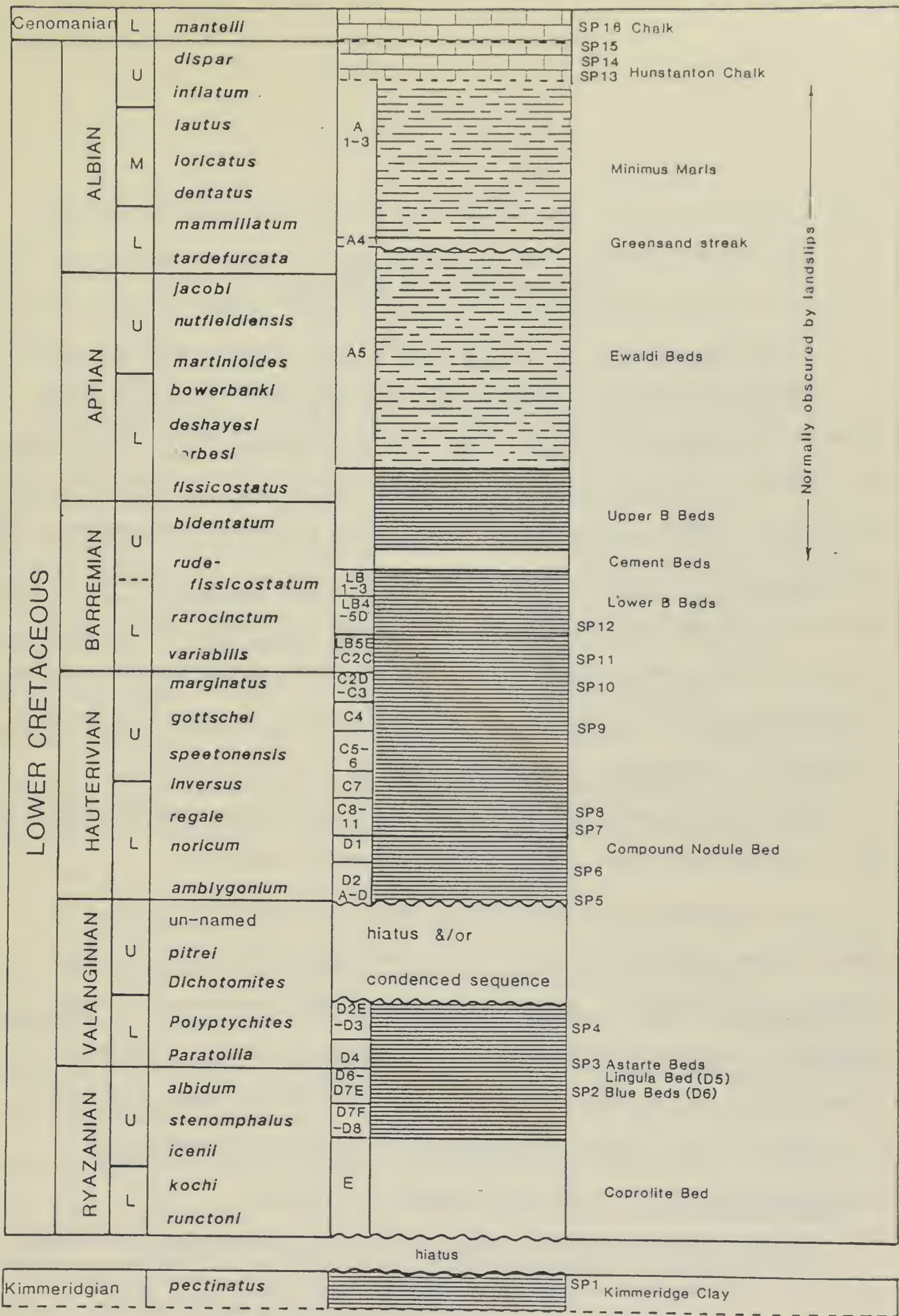
Locality 7: Reighton Bay, Speeton



■■■■ concrete blocks ■ pill box

400m





LOCALITY 10: REIGHTON BAY

LOCALITY 8: ROBIN HOOD'S BAY

Although Robin Hood's Bay provides the best exposure of the Lower Lias in Yorkshire, published accounts on the lithology and stratigraphy are lacking, the best discussions being by Bairstow (in Torrens, 1969) and Cope et al. (1980). Lower Sinemurian to Lower Pliensbachian mudstones and siltstone with thin limestones and nodule horizons are represented at the locality, and the *Semicostatum* to *Davoei* zones are recognisable. It is worth spending a few minutes viewing the bay from the car park above the village, from which vantage point, the Robin Hood's Bay Dome can be seen, picked out by the gentle dips in the curving wave cut platform.

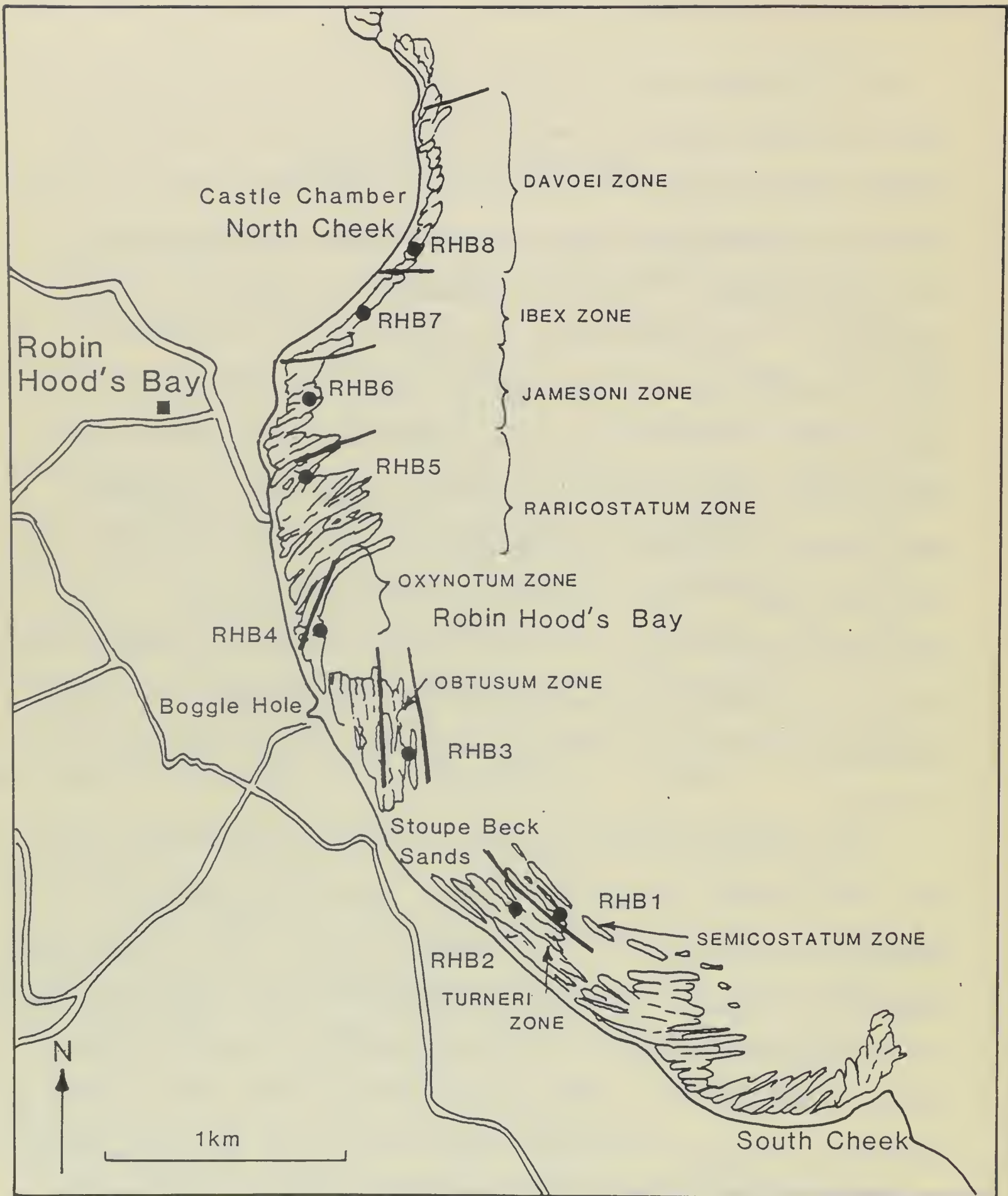
There are no published details on the Lias Ostracods at Robin Hood's Bay, although Park (1984, MS) has made a detailed analysis.

In the southern part of the bay, south of Stoupe Beck Sands, the *Semicostatum* zone is present at the seaward edge of the rock platform (SAMPLE POSITION RHB1). Here *Ogmoconchella danica* Michelsen is found abundantly together with *Progonoidea reticulata* (Klingler & Neuweiler). Closer to the shore, the *turneri* Zone (SAMPLE POSITION RHB2) contains a low diversity fauna including *Ogmoconchella danica* and *Kinkelinella* (*Ektyphocythere*) sp. cf. *K. (E.) vitiosa* (Apostolescu).

Stratigraphically higher ammonite zones are present between Stoupe Beck Sand and Boggle Hole, although the ostracod content is sparse. *Ogmoconchella danica*, *Kinkelinella* (*Ektyphocythere*) sp. cf. *K. (E.) vitiosa* and *Bairdia gantoftensis* Sivhed can be expected in the *Obtusum* Zone (SAMPLE POSITION RHB3) and again in the *Oxynotum* Zone a little further north (SAMPLE POSITION RHB4).

Deposits forming the rock platform at the point where the small road from the village reaches the beach, fall within the Raricostatum Zone (SAMPLE POSITION RHB5). Here, the ostracod assemblage is again composed of mainly of Ogmoconchella danica and Kinkelinella (Ektyphocythere) sp. cf. K. (E.) vitiosa, although rare Ogmoconchella gruendeli may also be recovered. The Jamesoni Zone, at the base of the Pliensbachian, contains a much improved fauna, both in terms of diversity and preservation. In the northern corner of the bay (SAMPLE POSITION RHB6), Ogmoconchella aequalis (Herrig), O. danica, O. gruendeli, Ogmoconcha eocontractula, Kinkelinella (Ektyphocythere) foveolata (Michelsen), Pleurifera harpa (Klingler & Neuweiler) and Pseudomacrocypris subtriangularis Michelsen are present in large numbers.. In addition, rare specimens of Isobythocypris elongata (Blake), Ogmoconchella sp. cf. O. mouherensis (Apostolescu) and Monoceratina multistriata Michelsen may also be found.

On the southern flank of North Cheek (SAMPLE POSITION RHB7), the Ibex Zone yields abundant Ogmoconchella danica, Bairdia gantoftensis and Gammacythere ubiquita Malz & Lord, together with less common Ogmoconchella gruendeli, O. aequalis, Ogmoconcha transversa (Gruendel), Pleurifera harpa and Isobythocypris elongata. Finally, just to the south of Castle Chamber, mudstones of the Davoei Zone can be seen. The ostracod fauna is very sparse and poorly preserved at this sample point, but Ogmoconchella danica, O. gruendeli, O. aequalis, Ogmoconcha transversa, Gammacythere ubiquita and Isocypris elongata may be collected.



Locality 8: Robin Hood's Bay

LOCALITY 9: SOUTH CAVE

North of the Humber Estuary, a number of quarries situated in the South Cave area, expose good sections of Cave Oolite (=Lincolnshire Limestone). One quarry, Eastfield Quarry (National Grid Reference SE 9155 3245), at one time exposed the marine marls underlying the oolite, but all that now remains is a dump of purple-brown and grey clay rich in ostracods.

THE CAVE OOLITE

Here the Cave Oolite is a cross-bedded grainstone, quarried for road metal or as building stone. Faunally, the ostracods are of the same species as may be extracted from the Lincolnshire Limestone, but are generally poorly preserved.

THE BASEMENT BEDS

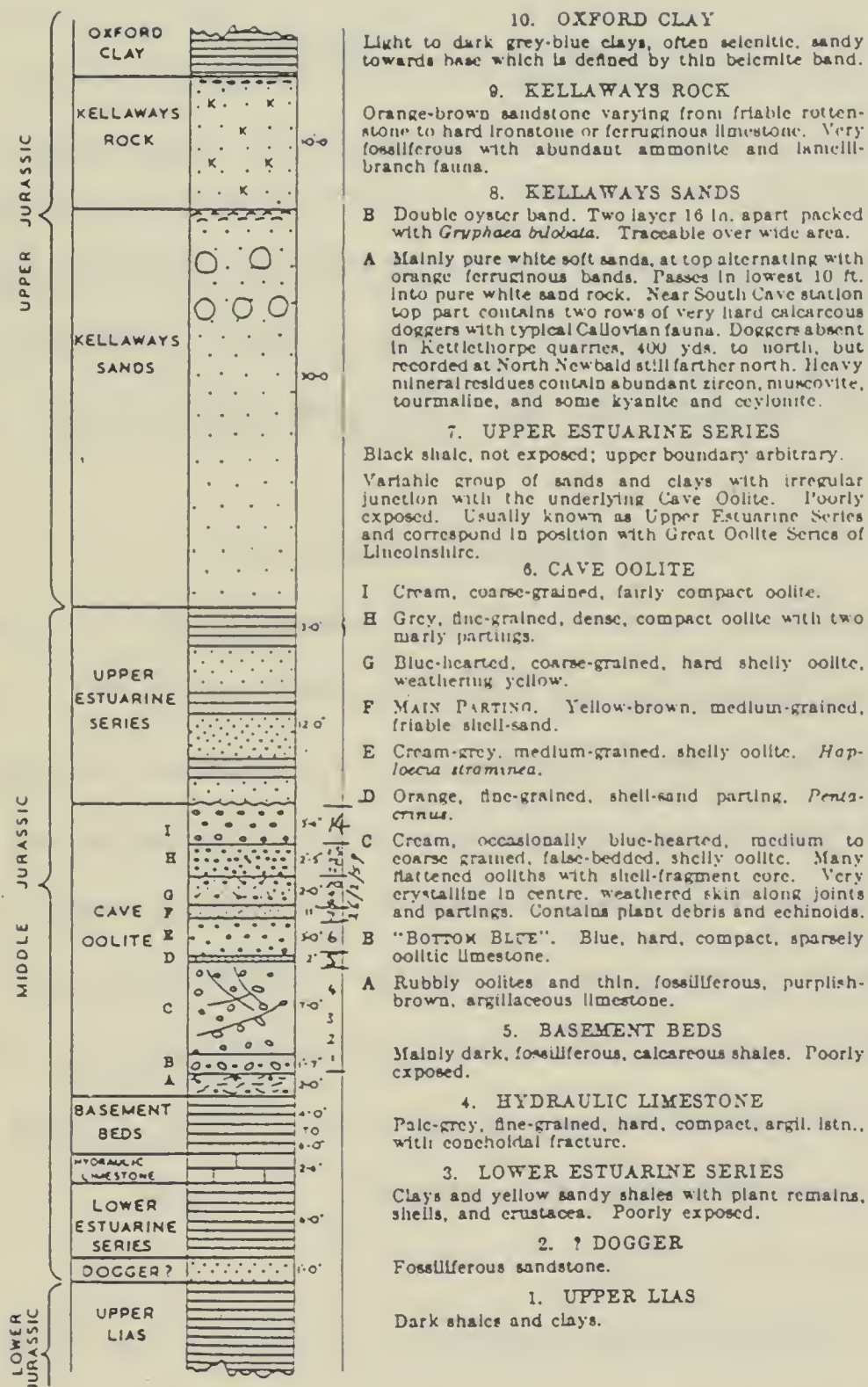
The section drawn by Neale (1958) is used here to illustrate the sequence developed in the area. The clays of the basement beds contain an extremely rich and very well preserved ostracod fauna of which many species are represented by an almost complete range of instars. This is taken to be indicative of a very quiet marine environment with no winnowing or sorting action. The ostracod fauna as listed, is indicative of the Concavum ammonite Zone:

Cytherelloidea eastfieldensis Bate, Paracypris bajociana, Monoceratina vulsa, Progonocythere cristata, P. reticulata Bate, Acanthocythere (Proacanthocythere) faveolata, Aulacocythere punctata, Dolococythere maculosa, Micropneumatocythere convexa Bate, Pneumatocythere bajociana

Bate, Pleurocythere kirtonensis, Homocytheridea cylindrica Bate,
Tetracytheridea punctata Bate, Asciocythere lacunosa Bate, Eocytheridea
elongata Bate, E. lacunosa Bate, Paraschuleridea ornata Bate, P. sp.,
Praeschuleridea decorata Bate, P. subtrigona, Cytheropterina comica Bate,
C. gravis Bate, Kirtonella plicata Bate, Ektyphocythere triangula,
Kinkelinella? bajociana Bate, Systemocythere exilofasciata Bate.



Locality 9: South Cave area



The Jurassic succession in the South Cave area.

LOCALITY 10: CLOUGHTON

North of Scarborough, on the north east Yorkshire coast, excellent exposures of marine and non-marine Middle Jurassic deposits abound. One of these at Hundale Point, Cloughton, exposes a complete section of the marine Scarborough Formation (National Grid Reference TA 0255 9485).

THE SCARBOROUGH FORMATION

The most complete sections of the Scarborough Formation occur in this region, close to the axis of the subsiding Cleveland Basin. The succession at Hundale Point has a total thickness of 19m, although Hemingway (1974, p.200) includes the beds of sandstone, which both underlie and overlie the marine shales of the Scarborough Formation. The basal sandstone, however, is not considered to be part of this marine transgression, as it is followed by marine shales of the oldest Glyptocythere polita Zone at Hundale and by the younger shales of the Glyptocythere scitula Zone at Cayton Bay. It is, therefore, more realistic to consider it as part of the underlying deltaic succession.

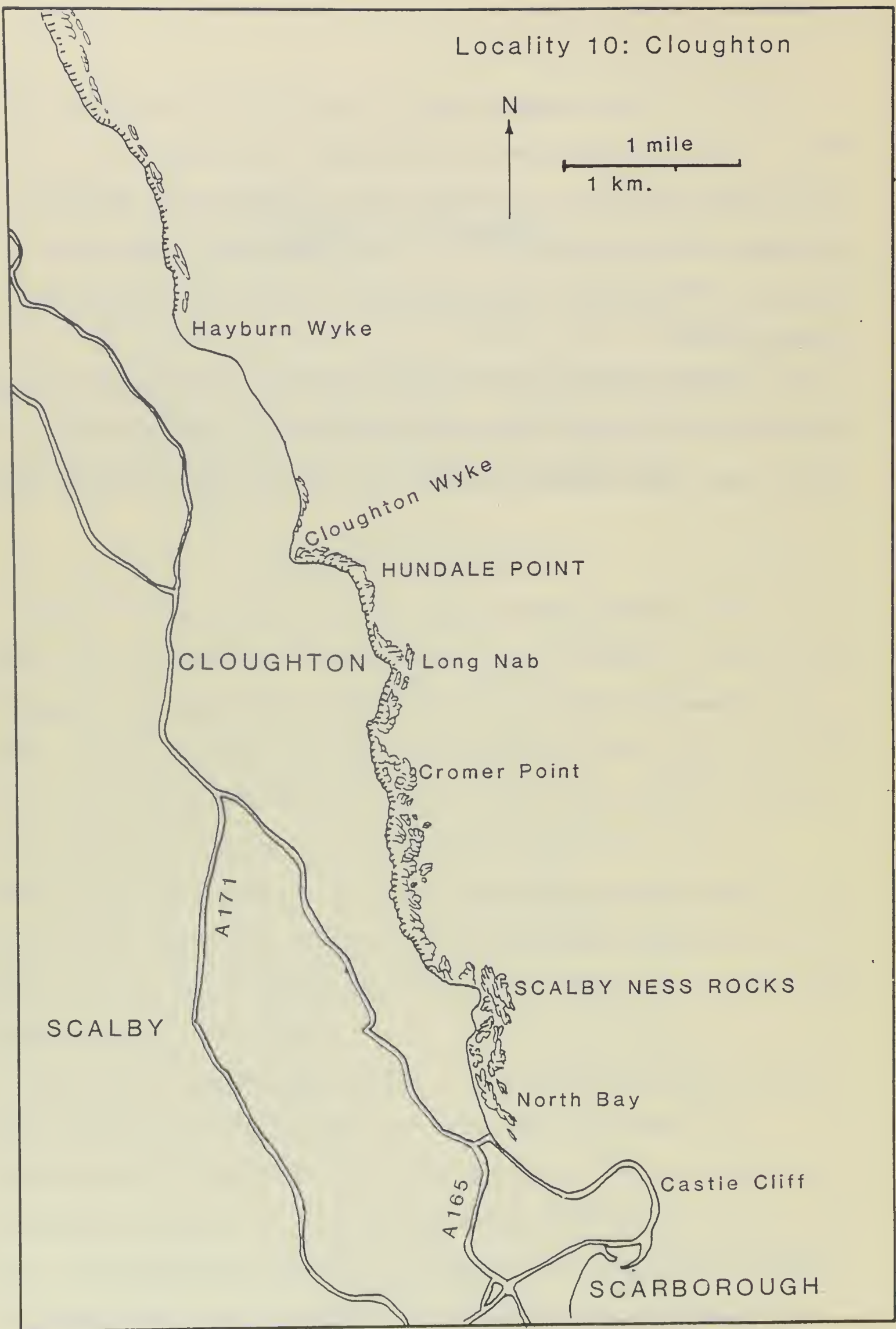
The zone of Glyptocythere scitula is represented in the Transitional Shales, White Nab Ironstone Member and Ravenscar Shale Member (in descending order), from which the following ostracods may be collected: Glyptocythere scitula Bate, Fuhrbergiella (Praefuhrbergiella) horrida Brand & Malz, Praeschuleridea subtrigona intermedia Bate, Vernoniella bajociana Bate, Monoceratina scarboroughensis Bate, Ljubimovella piriformis Malz, Cloughtonella rugosa Bate and Systemocythere ovata Bate.

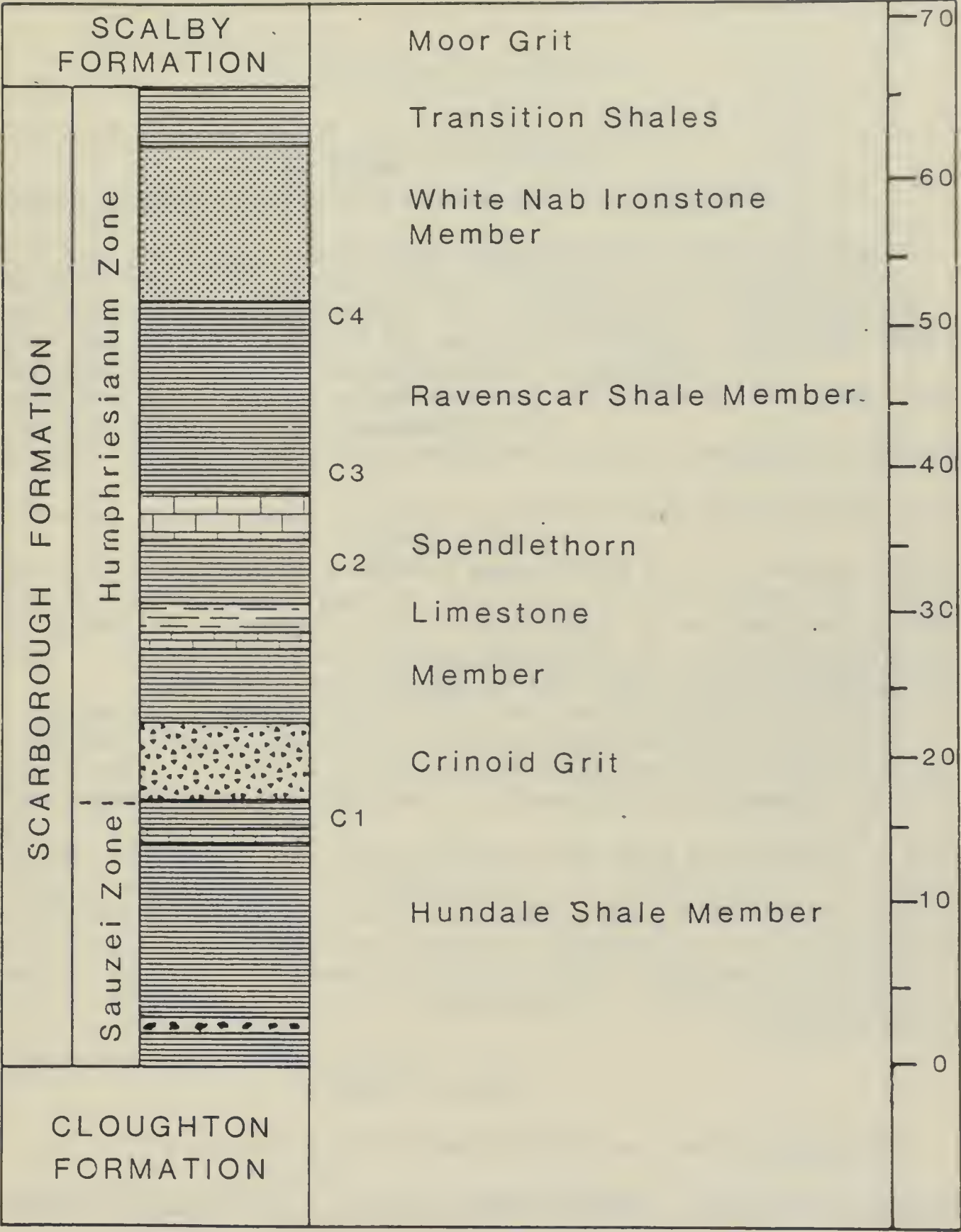
The zone of Glyptocythere polita is represented in the Hundale Shale Member. The following ostracods can be found in the member:

Glyptocythere polita Bate, G. costata Bate, Praeschuleridea subtrigona intermedia, Malzia unicarinata Bate, M. bicarinata Bate, Vernoniella bajociana, Fuhrbergiella (Praefuhrbergiella) horrida and Progonocythere acuminata Bate.

The Crinoid Grit separates the lithological units assigned to the two ostracod zones. To date, the Crinoid Grit has been assigned to the G. scitula Zone, but no ostracod evidence has been obtained to confirm this.

Locality 10: Cloughton





Locality 10: Cloughton (Hundale Point)

LOCALITY 11: CAYTON BAY

This locality is an extended coastal section (National Grid Reference TA 0845 8440) that stretches from Yons Nab Headland to High Red Cliff, in Cayton Bay. At low tide, the Sycharham Member of the Cloughton Formation (Deltaic) is exposed with the overlying Cayton Bay Formation (Millepore Oolite and Yons Nab Beds) forming a scarp and shale gulley respectively. A reduced sequence of the Scarborough Formation is located within the low cliff at Yons Nab and is represented only by sediments belonging to the Glyptocythere scitula Zone (the G. polita Zone is missing).

The Upper Cornbrash outcrops in the fore shore and represents a marine Callovian transgression followed by a regressive phase in which marine sands (the Kellaways Rock and Hackness Rock) were deposited. Marine sands and clays of Oxfordian age occur in the High Red Cliff, where the Oxford Clay facies is overlain by the massive calcareous sandstones of the Lower Calcareous Grit.

YONS NAB BEDS

Ostracods present in the Yons Nab Beds include:

Paracypris bajociana, Progonocythere cristata, Micropneumatocythere convexa, M. globosa Bate, Pneumatocythere bajociana, Dolococythere maculosa, Asciocythere lacunosa, Eocytheridea? acuta Bate, E. lacunosa, E. faveolata Bate, E. carinata Bate, E? erugata, Praeschuleridea subtrigona magna Bate, P. decorata, Cytheropterina plana Bate, Kirtonella plicata, K. reticulata Bate, Ektyphocythere triangula, Systemocythere exilofasciata and Homocytheridea cylindrica.

THE SCARBOROUGH FORMATION

Ostracods present in the Scarborough Formation include:

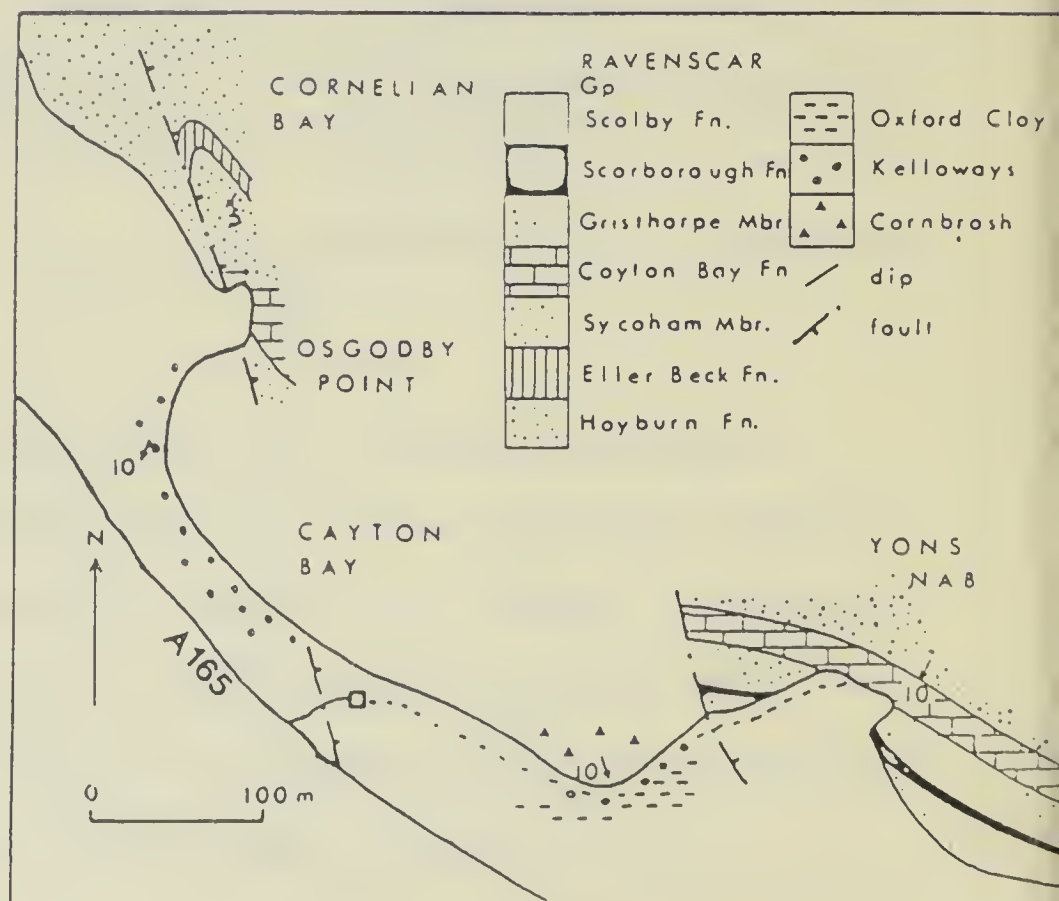
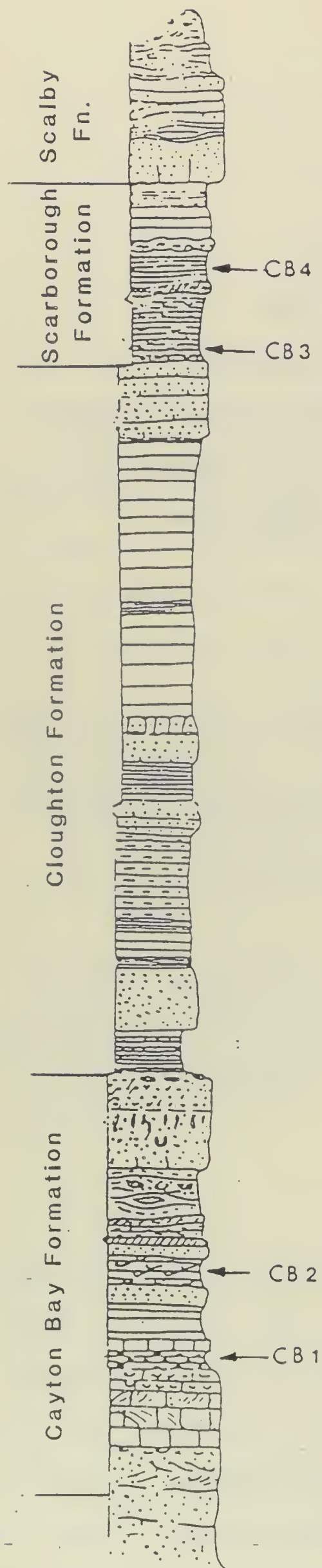
Glyptocythere scitula, Vernoniella bajociana, V? caytonensis Bate,
Praeschuleridea subtrigona intermedia, Systemocythere ovata, Paracypris
bajociana, Caytonidea faveolata Bate, Pleurocythere sp., Fuhrbergiella
(Praefuhrbergiella) horrida, Paracytheridea? caytonensis Bate,
Progonocythere acuminata, P. yonsnabensis Bate.

OXFORD CLAY

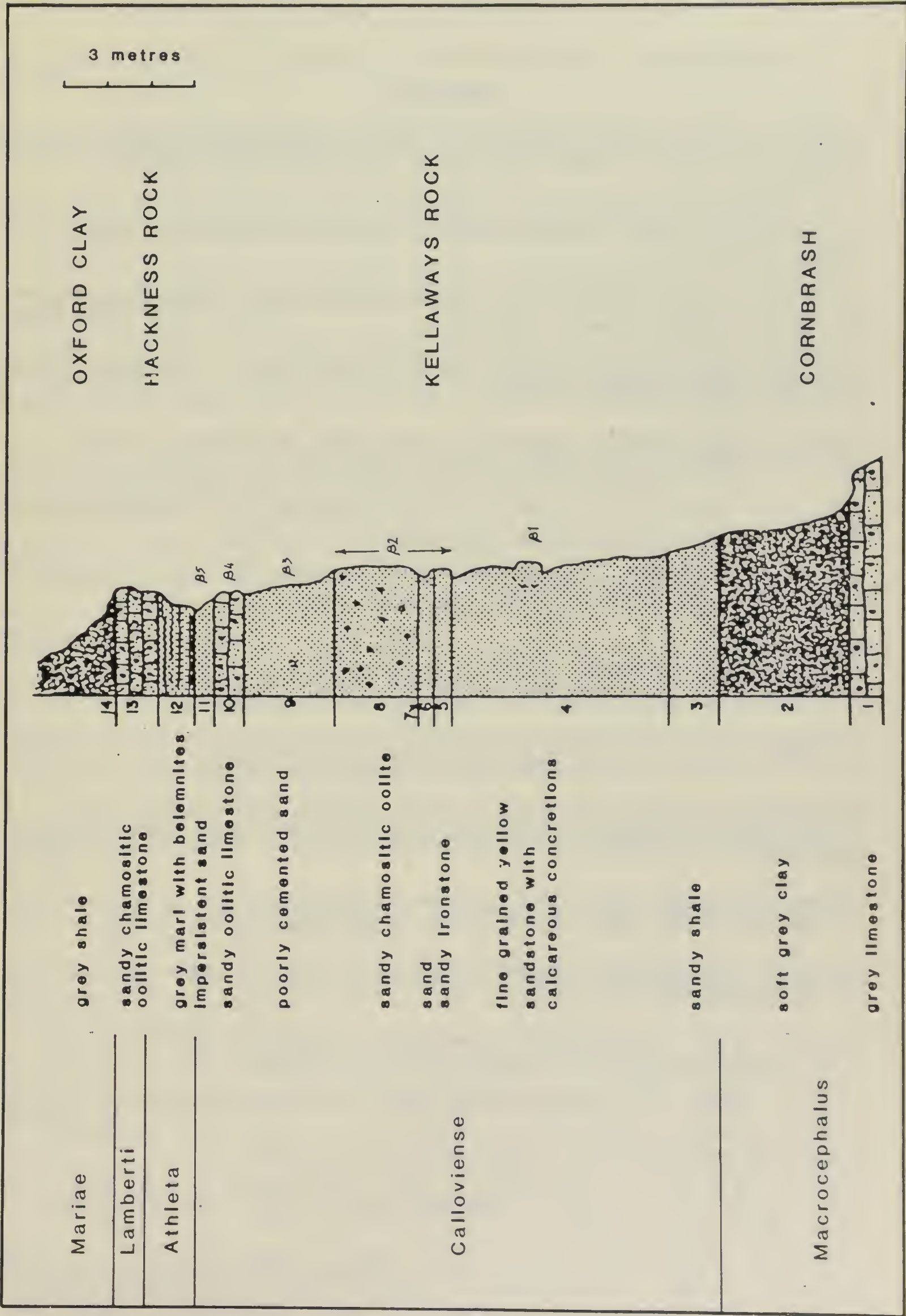
The Callovian (Koenigi Zone) part of the Oxford Clay at Cayton Bay contains only sparse ostracods including Galliaecytheridea sp. and Glabellacythere sp. The assemblage from the Lower Oxfordian (Mariae Zone) part of the formation, however, is more diverse and the following ostracods may be collected:

Nophrecythere oxfordiana Lutze, Monoceratina cf. scrobicularis, M. vulsa,
Procytherura tenuicostata Whatley, Polycope sububiquita Whatley, Cytherella
index Oertli, Procytheropteron sp., Paracypris sp., Schuleridea triebeli
and Eucytherura (Vesticytherura) sp.

Locality 11: Cayton Bay



Generalised section of the Kellaways and Hackness Rocks, Red Cliff



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